The Thesis Committee for Laura Emilia Sigelmann
Certifies that this is the approved version of the following Thesis:

Climate Change and Migration in Cambodia: An Analysis of Spatiotemporal Trends in Water Availability and Migration

APPROVED BY
SUPERVISING COMMITTEE:

Bridget Scanlon, Supervisor

Joshua Busby, Co-Supervisor

Michael Findley

Climate Change and Migration in Cambodia: An Analysis of Spatiotemporal Trends in Water Availability and Migration

by

Laura Emilia Sigelmann

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Dedication

This thesis is dedicated to those without whom I could not have finished: my family, my friends, and most importantly, my cat and a cheap box of wine.

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Thank you to my advisors, Bridget Scanlon and Joshua Busby, for your guidance in this research. Thank you Jaganath Sankaran, for answering my myriad of statistical questions and offering sound quantitative advice. Thank you to Caleb Ray, for your role as a sounding board and editor. Special thanks to the Brumley Next Generation Scholars program and my family and friends, all of whom helped fund my fieldwork in Cambodia. Most importantly, thank you to Bora Soeung and the teams at Aphivat Strey and Cambodia Development Resource Group, who unquestioningly aided my research and welcomed me into their villages and homes. This research would not be possible without you.

Abstract

Climate Change and Migration in Cambodia: An Analysis of Spatiotemporal Trends in Water Availability and Migration

Laura Emilia Sigelmann, MGPS, MSEER

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Supervisor: Bridget Scanlon and Joshua Busby

Cambodia is a small fragile state in Southeast Asia that is highly exposed to the effects of climate change. While there is a burgeoning body of research on the effects of climate change on security outcomes, there is limited research on the relationship between climate change and migration, particularly in Cambodia. The purpose of this study is twofold: first, to analyze subnational climate vulnerabilities in Cambodia with a specific emphasis on water availability; second, to analyze the relationship between water availability and migration in Cambodia. The study first uses a mix of quantitative and qualitative data to establish the political, economic, and social conditions necessary for climate change to affect migration. Then, the study uses Esri's Emerging Hot Spot Analysis tool to identify precipitation trends on a subnational level. Finally, the study uses qualitative and quantitative data, including focus group interviews, to analyze subnational migration patterns in relation to subnational precipitation patterns and provide a holistic picture of Cambodia's climate-migration nexus. The study finds that precipitation is decreasing in the northwest provinces of Banteay Meanchey, Battambang, Oddar

Meanchey, and Siem Reap, where the bulk of the population is reliant on traditional rice agriculture, which is highly vulnerable to the effects of climate change. The study also concludes that households that have experienced crop loss, drought, and poor rainfall are more likely to have a family member migrate the following year. If the northwest continues to experience a drying trend, it is likely that more individuals will migrate from these provinces in the future. Future research should address two things: first, how climate change projections for the country vary spatially and temporally; and second, how climate change and migration are quantitatively linked. Finally, the Cambodian government and international organizations should direct funding towards research to better understand the situation in northwestern Cambodia and policies that increase the resilience of the region's agricultural communities.

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Chapter 1: Introduction

Cambodia, a small, low-income, Southeast Asian country, is a highly fragile state due to the environmental vulnerabilities, population pressures, and governance problems it faces. Climate change, including medium- and long-term changes in precipitation, temperature, and weather systems due to human emissions of greenhouse gasses, compounds these issues. Cambodia is dependent on the monsoon rains for agriculture and climate change is likely to increase the unpredictability of the monsoon pattern, exposing populations in the Mekong River Basin and around Tonle Sap Lake to heavy rainfall variation.[1] Potential consequences include water scarcity, food scarcity, agricultural loss, property loss, lowered biodiversity, and the spread of vector-borne diseases.[2] A significant proportion of Cambodians are at risk, as 45% of the population lives in high climate exposure areas and 20% of the population lives in very high exposure areas.[3]

Low economic diversity and poor governance exacerbate these risks. Approximately 67% of Cambodians rely on agriculture for a source of income.[4] The primary crop, rice, depends on water availability and rice yields are predicted to decrease under most scenarios from the Intergovernmental Panel on Climate Change (IPCC).[5] Cambodia's government is nominally democratic, but President Hun Sen and the

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[1] Amodwala, Juhi. 2018. "Cambodia." Country Mini-Brief. Strauss Center Brumley Next Generation Fellows Program.

[2] Hoegh-Guldberg, O, D Jacob, M Taylor, M Bindi, S Brown, I Camilloni, A Diedhiou, et al. 2018. "Impacts of 1.5 C Global Warming on Natural and Human Systems." In Global Warming of 1.5 C: An IPCC Special Report on the Impacts of Global Warming of 1.5 C above Pre-Industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty. Geneva, Switzerland.

[3] Moran, Ashley, Joshua Busby, Clionadh Raleigh, Todd Smith, Roudabeh Kishi, Nisha Krishnan, and Charles Wight. 2018. "The Intersection of Global Fragility and Climate Risks." USAID.

[4] World Bank Group. World Bank Open Data. https://data.worldbank.org

[5] Hoegh-Guldberg, O, et al

Cambodia Peoples' Party (CPP) have retained power for over 30 years. The government relies on foreign aid for 30% of its budget and critical agencies such as the Ministry of Agriculture have 100% financing gaps for climate projects.[6] In a report for USAID, Moran et al. categorized Cambodia as highly fragile, based largely on poor effectiveness and legitimacy indicators.[7] Polity IV has also rated Cambodia's governance poorly, with low scores for democracy and political competition, showing an increasing trend towards authoritarianism.[8] Without proper government support, the lack of state capacity and poor adaptive capacity leaves a large proportion of the population deeply exposed to climate hazards. Climate change is an increasing threat to security, and the combination of exposure and poor governance makes Cambodia particularly vulnerable to climate change-related risks.[9] However, there is significant debate in the climate security field over the nature of the relationship between climate change and security risks.

The purpose of this research is to analyze climate vulnerabilities and security risks in Cambodia. This research uses a combination of quantitative data measures and qualitative interviews to offer a holistic picture of the climate-security vulnerability nexus in Cambodia and propose policy solutions geared toward reducing climate vulnerability and security risks.

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[6] Seyma, Un. 2018. "Review of Implementation Challenges Posed by the Climate Change Action Plan 2014-2018 in Cambodia: Case Studies of Three Ministries." Phnom Penh Cambodia: Parliamentary Institute of Cambodia. This research indicates that while climate projects are planned, they are meeting 0% of their funding needs for said projects.

[7] Moran, Ashley et al.

[8] "Polity IV Project: Home Page," accessed November 8, 2018, http://www.systemicpeace.org/polity/polity4x.htm. In 2017, Cambodia had a score of 0 on Democracy and 4 on Autocracy. Both are scored on a composite scale of 0-10, where 10 indicates strong institutionalized systems.

[9] "Report on Effects of a Changing Climate to the Department of Defense" (Office of the Under Secretary of Defense for Acquisition and Sustainment, January 2019), https://www.documentcloud.org/documents/5689153-DoD-Final-Climate-Report.html.

Chapter 2: Literature Review

The role of climate change in accelerating or exacerbating conflict is a growing concern. Organizations such as the U.S. Department of Defense, the United Nations Security Council, and the U.S. intelligence community have recognized the role of climate change in acting as a "threat multiplier," exacerbating existing conflict or creating conditions for new conflict to break out.[10] However, describing climate change as a threat multiplier is not useful without a deeper understanding of the circumstances under which climate change leads to negative security outcomes.

The mechanisms underlying the connection between climate change and conflict are often ambiguous or difficult to statistically link. Several studies have aimed to draw quantitative connections between climate effects such as temperature or rainfall variability and armed conflict, but the results are mixed.[11] Early literature focused on determining whether there was a direct correlation between climate effects and the incidence of violence, but more recent literature has moved towards studying the indirect pathways between climate effects and different types of conflict.[12] Climate change alone is unlikely to cause conflict. Rather, climate change affects the "dynamics of interaction between societal actors."[13]

There are four primary causal pathways: agricultural production and food prices, economic growth, migration, and disasters. However, not all of these are relevant in

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[10] "Report on Effects of a Changing Climate to the Department of Defense."
"Climate Change Recognized as 'Threat Multiplier', UN Security Council Debates Its Impact on Peace," UN News, January 25, 2019, https://news.un.org/en/story/2019/01/1031322.
Daniel Coats, "Worldwide Threat Assessment of the US Intelligence Community" (Senate Select Comittee on Intelligence, January 29, 2019).

[11] Joshua Busby, "Taking Stock: The Field of Climate and Security," *Current Climate Change Reports* 4, no. 4 (December 2018): 338–46, https://doi.org/10.1007/s40641-018-0116-z.

[12] Busby.

[13] Halvard Buhaug, "Climate Change and Conflict: Taking Stock," *Peace Economics, Peace Science and Public Policy* 22, no. 4 (December 1, 2016): 331–38, https://doi.org/10.1515/peps-2016-0034.

Cambodia. Many rural Cambodians are subsistence farmers and are highly dependent on natural resources for their livelihoods, making them extremely sensitive to changes in rainfall and other water resources. Given this high dependence on natural resources, the most likely causal pathway for climate to cause security issues in Cambodia is through decreased agricultural production and resulting migration. Cambodia is a Least Developed Country, with an annual gross national income per capita of $1,390 and a population of 16 million.[14] The poverty rate has decreased from 53% in 2004 to 18% in 2012. This decrease in poverty is fragile, however, as more than 60% of the reduction was in the agricultural sector, where a loss of $0.70/day would return the poverty rate back to 40%.[15] Seventy-nine percent of the population resides in rural areas while 67 percent of the population is employed in agriculture. Rice is the most common crop, with around 70% of the farmland under rice production.[16] Despite the high employment in agriculture, only 23.4% of Cambodia's Gross Domestic Product (GDP) comes from agriculture, forestry, and fishing.[17] There is emerging data on growing migration out of Cambodia's rural areas in response to changes in rainfall variability and agricultural output.[18]

AGRICULTURE AND FOOD PRICES

Numerous studies have looked at the effect of agricultural production and food prices on conflict. Food prices, food production, and food insecurity are the causal pathways between climate change and security events, although studies have treated these

[14] World Bank, "Cambodia | Data," accessed November 27, 2018, https://data.worldbank.org/country/Cambodia.
[15] "Cambodian Agriculture in Transition: Opportunities and Risks," Text/HTML, World Bank, accessed December 5, 2019, https://www.worldbank.org/en/country/cambodia/publication/cambodian-agriculture-in-transition-opportunities-and-risks.
[16] "Cambodian Agriculture in Transition."
[17] World Bank, "Cambodia | Data."
[18] "Migration and Families Left Behind in Cambodia," International Organization for Migration, February 2, 2018, https://www.iom.int/news/migration-and-families-left-behind-cambodia.

variables differently. Decreases in agricultural production can lower the opportunity cost of rebelling by diminishing formal sources of income, while higher food prices may be a source of grievance for citizens.[19] Lowered agricultural yield and loss of livelihoods may lead to increases in migration, stressing government resources or placing pressure along ethnic fissure lines.

Wischnath and Buhaug identified three processes through which loss of food production can escalate into conflict: lowered opportunity cost of rebelling, increased opportunities for recruitment, and widespread social grievances.[20] The study focused on changes in food production rather than rainfall variability, assuming that changes in agricultural production would capture broader changes in climate conditions. Using political violence in India from 1980 to 2011, they examined how yearly fluctuations in food production affected the severity of ongoing conflicts. They argued that environmental stress put people's livelihoods at risk, particularly those dependent on agricultural output. The loss of harvests and corresponding income would result in higher unemployment. If the state failed to support such individuals, incentives to join an ongoing insurgency would increase. Ultimately, the study found that harvest loss was associated with increased levels of political violence. However, their focus on ongoing conflict narrowed the scope of the study and precluded any conclusions about the pathways to conflict.

A broad literature review by Hendrix and Brinkman discussed the relationship between food insecurity and civil and communal conflict.[21] Civil conflict affects almost

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[19] Emily Meierding, "Climate Change and Conflict: Avoiding Small Talk about the Weather," *International Studies Review* 15, no. 2 (June 2013): 185–203, https://doi.org/10.1111/misr.12030.

[20] Gerdis Wischnath and Halvard Buhaug, "Rice or Riots: On Food Production and Conflict Severity across India," *Political Geography* 43 (November 2014): 6–15, https://doi.org/10.1016/j.polgeo.2014.07.004.

[21] Cullen Hendrix and Henk-Jan Brinkman, "Food Insecurity and Conflict Dynamics: Causal Linkages and Complex Feedbacks," *Stability: International Journal of Security & Development* 2, no. 2 (June 17, 2013): 26, https://doi.org/10.5334/sta.bm.

exclusively food-insecure and less-developed countries. While some researchers argue that military organizations recruit fighters through promises for food and shelter, the empirical evidence is mixed.[22] Acute food insecurity may actually diminish conflict by reducing available resources and hindering political participation. Communal conflict affects areas where land and water are scarce, although the link to climate shocks is again uncertain. While some research indicates communal conflict is more prevalent during times of abundance, other studies indicate it is more prevalent during times of food insecurity.[23]

Lagi et al. examined the role of global food prices in uprisings in the Middle East in 2008 and 2011, arguing that large peaks in global food prices coincided with food riots and protests associated with major unrest.[24] They argued food prices were the precipitating condition for social unrest, particularly for food-importing countries with widespread poverty. However, Smith counters that relating global food prices to country-level conflict simplifies complex relationships between international and domestic prices, given that global prices may not be the actual prices people pay.[25] While Lagi et al. researched conflict specific to food-related grievances, Smith argued that populations perceive their hardship differently, and grievances may not be addressed the same way. Additionally, states may insulate their citizens from food price shocks through domestic subsidies.

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[22] Ana Arjona and Stathis Kalyvas, "A Micro-Level Approach to Armed Organizations" (Yale University, February 2008).

Macartan Humphreys and Jeremy M. Weinstein, "Who Fights? The Determinants of Participation in Civil War," *American Journal of Political Science* 52, no. 2 (April 2008): 436–55, https://doi.org/10.1111/j.1540-5907.2008.00322.x.

[23] Ole Magnus Theisen, "Climate Clashes? Weather Variability, Land Pressure, and Organized Violence in Kenya, 1989–2004," *Journal of Peace Research* 49, no. 1 (January 2012): 81–96, https://doi.org/10.1177/0022343311425842.

Mareike Schomerus and Tim Allen, "Southern Sudan at Odds with Itself: Dynamics of Conflict and Predicaments of Peace," January 2010.

[24] Marco Lagi, Karla Z. Bertrand, and Yaneer Bar-Yam, "The Food Crises and Political Instability in North Africa and the Middle East," *ArXiv:1108.2455 [Physics]*, August 11, 2011, http://arxiv.org/abs/1108.2455.

[25] Todd Smith, "Research Brief - Food Price Spikes and Social Unrest in Africa" (Climate Change and African Political Stability, April 2013).

Smith's analysis addressed the correlation between rainfall scarcity and conflict. While there may not have been direct conflict over water resources, he argued that rainfall scarcity affected agriculture, thereby changing food prices and leading to security consequences. All else equal, the study found accumulated rainfall of one standard deviation below the long-term mean was associated with a 0.264% increase in domestic food prices from the previous month and that a 1% increase in the domestic consumer food price index led to a 24.1% increase in the odds of unrest. The study concluded that sudden increases in consumer food prices in a given month contributed significantly to an increase in the probability of any kind of social unrest in that month.

However, different types of states treat food prices and subsidies differently. Hendrix and Haggard found a divide between democracies and autocracies.[26] They found that governments often shift food subsidies from rural residents to urban consumers, especially in autocratic governments where discontented urban populations pose a risk to authoritarian powers. Additionally, the study found that democracies and hybrid regimes experience more urban unrest during times of high food prices. In autocracies, they found no relationship between food prices and urban unrest. [27]

Finally, political exclusion and ethnic fissures may also play a role in the agriculture-conflict nexus. Von Uexkull et al. took an innovative approach by examining ethnic groups, drought during the primary crop season, and political exclusion to find a statistically significant link between climate change and conflict in Asia and Africa.[28] They theorized that the vulnerability to climate extremes is a function of groups' dependence on

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[26] Cullen S Hendrix and Stephan Haggard, "Global Food Prices, Regime Type, and Urban Unrest in the Developing World," *Journal of Peace Research* 52, no. 2 (March 2015): 143–57, https://doi.org/10.1177/0022343314561599.

[27] Hybrid regimes are mixed regimes that are neither fully democratic nor fully autocratic.

[28] Nina von Uexkull et al., "Civil Conflict Sensitivity to Growing-Season Drought," *Proceedings of the National Academy of Sciences* 113, no. 44 (November 1, 2016): 12391–96, https://doi.org/10.1073/pnas.1607542113.

natural resources, the sensitivity of the ecosystem, and the group's coping ability. This leads communities on non-irrigated lands to be particularly vulnerable, especially if they have low socioeconomic development, a history of conflict, and limited access to economic and social capital. Their analysis found that drought had little effect on the short-term conflict risk under most conditions. However, for agriculturally dependent and politically excluded groups in poor countries, local drought increased the likelihood of sustained violence.

MIGRATION

Migration is a relatively unexplored pathway, although it is increasingly important. A 2018 World Bank report noted that climate change could force 143 million people to move internally by 2050, 40.5 million of those in South Asia.[29] It is likely that urban areas will become hotspots of in-migration and rural-to-urban migration will grow. Some literature has suggested that climate-induced migration could destabilize neighboring states or bring ethnic groups with divergent beliefs in contact with each other.[30] Conversely, climate migration due to crises may elicit empathy rather than conflict – receiving countries may view such migration as an act of nature.[31] Regardless, given the influx in Central American migration to the United States and increasing anti-immigrant rhetoric in the U.S., which some have linked to climate factors, it's clear that large-scale migration due to climate change has serious security implications.[32]

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[29] Kanta Kumari Rigaud et al., "Groundswell: Preparing for Internal Climate Migration" (The World Bank, March 19, 2018).
[30] Rafael Reuveny, "Climate Change-Induced Migration and Violent Conflict," *Political Geography* 26, no. 6 (August 2007): 656–73, https://doi.org/10.1016/j.polgeo.2007.05.001.
[31] Clionadh Raleigh, Lisa Jordan, and Idean Salehyan, "Assessing the Impact of Climate Change on Migration and Conflict" (The World Bank, 2008).
[32] Laura Sigelmann, "The Hidden Driver: Climate Change and Migration in Central America's Northern Triangle" (American Security Project, September 6, 2019),

Research by Koubi et al. shows a distinction between the effects of long-term and sudden-onset environmental events on migration.[33] Their analysis found that perceptions of long-term environmental events reduced migration while perceptions of sudden-onset environmental events increased the likelihood of migration. However, they simply addressed the environmental motivation to migrate rather than the host-country consequences. Reuveny examined 38 cases of environmental migration and found that the majority had multiple environmental factors: 27 had land degradation, 19 droughts, 17 deforestation, 15 water scarcity, 9 floods, 7 storms, and 5 famines.[34] Conflict was present in 19 of the 38 cases. However, Reuveny did not directly link those conflicts to the presence of migrants and the sample was too small to generalize.

Salehyan and Gleditsch found that refugees can create conflict with existing residents if they compete for finite government resources.[35] They argue that population movements can help spread conflict, particularly if they alter the ethnic composition of a state, exacerbate economic competition, or facilitate the flow of arms or ideologies. However, they do not address climate migrants, which Raleigh et al. suggest are different from refugees because their movements are more likely to be temporary.[36] Further, climate migrants are more likely to elicit sympathy from receiving locations due to the perception that their migration was forced by nature. They are also more likely to be vulnerable and less likely to engage in conflict.

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https://www.americansecurityproject.org/perspective-climate-change-and-migration-in-central-americas-northern-triangle/.

[33] Vally Koubi et al., "Environmental Stressors and Migration: Evidence from Vietnam," *World Development* 79 (March 2016): 197–210, https://doi.org/10.1016/j.worlddev.2015.11.016.

[34] Reuveny, "Climate Change-Induced Migration and Violent Conflict."

[35] Idean Salehyan and Kristian Gleditsch, "Refugees and the Spread of Civil War," *International Organization* 60, no. 2 (2006): 335–66.

[36] Raleigh, Jordan, and Salehyan, "Assessing the Impact of Climate Change on Migration and Conflict."

Migration can also be seen as an intermediary and bidirectional causal variable. Freeman finds that directly connecting environmental change to migration and conflict misses important intervening variables.[37] She argues that attention needs to be paid to local-level manifestations of conflict and maladaptive migration. The study finds that, while environmental factors alone may not be necessary or sufficient to cause migration or conflict, they form part of a broader picture of migration and conflict. She suggests further research is needed to understand the patterns of interconnectedness and whether migration is truly an intermediary variable.

UNDERLYING CONDITIONS

One persistent question is whether political and social factors should be included as control variables in statistical models. A series of competing studies and responses between a group of Berkeley economists led by Hsiang and Burke and a group from Peace Research Institute Oslo (PRIO) led by Buhaug largely represents this debate. While the Berkeley scholars have found strong correlations between climate-related variables and conflict, PRIO scholars have countered their findings.

Burke et al. found that warmer temperatures led to increases in the likelihood of civil war and a follow-up meta-analysis found that each standard deviation in climate correlated to a 4% rise in interpersonal violence and 14% rise in intergroup conflict.[38] Buhaug countered that their use of country fixed-effects masked the important effects of

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[37] Laura Freeman, "Environmental Change, Migration, and Conflict in Africa: A Critical Examination of the Interconnections," *The Journal of Environment & Development* 26, no. 4 (December 2017): 351–74, https://doi.org/10.1177/1070496517727325.

[38] M. B. Burke et al., "Warming Increases the Risk of Civil War in Africa," *Proceedings of the National Academy of Sciences* 106, no. 49 (December 8, 2009): 20670–74, https://doi.org/10.1073/pnas.0907998106.

S. M. Hsiang, M. Burke, and E. Miguel, "Quantifying the Influence of Climate on Human Conflict," *Science* 341, no. 6151 (September 13, 2013): 1235367–1235367, https://doi.org/10.1126/science.1235367

politics. He argued that measures for ethno-political context, economic development, and time displayed significant effects on conflict and thus cannot be left out.[39] However, Hsiang et al. counter that the inconsistency is due to model selection and methodological differences. They argue that the use of fixed-effects standardizes differences between locations and is necessary to quantify the relationship between climate and conflict.[40] Additionally, they state that many typical control variables are correlated with climate variables, thus underestimating the effect of climate measures.

Similarly, a number of scholars identify institutions as a potential mediating factor that can amplify or diminish the risk of conflict. Busby highlights the importance of institutions and the supporting role that they play in diminishing or exacerbating conflict.[41] Salehyan and Hendrix as well as Hendrix and Haggard both split samples by regime type.[42] Von Uexkull et al. include the role of political exclusion in their model.[43] Tir and Stinnett find that effective river basin institutions reduce the risk of conflict by allocating water and mediating disputes.[44] The effects of these intervening variables are critical for understanding country-level causal pathways.

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[39] H. Buhaug, "Climate Not to Blame for African Civil Wars," *Proceedings of the National Academy of Sciences* 107, no. 38 (September 21, 2010): 16477–82, https://doi.org/10.1073/pnas.1005739107.

[40] S. M. Hsiang, M. Burke, and E. Miguel, "Quantifying the Influence of Climate on Human Conflict," *Science* 341, no. 6151 (September 13, 2013): 1235367–1235367, https://doi.org/10.1126/science.1235367.

[41] Buhaug, "Climate Change and Conflict."

[42] Cullen Hendrix and Idean Salehyan, "Climate Shocks and Political Violence: Beyond Scarcity, Beyond Africa" (Robert S. Strauss Center, 2012).

Hendrix and Haggard, "Global Food Prices, Regime Type, and Urban Unrest in the Developing World."

[43] von Uexkull et al., "Civil Conflict Sensitivity to Growing-Season Drought."

[44] Jaroslav Tir and Douglas M Stinnett, "Weathering Climate Change: Can Institutions Mitigate International Water Conflict?," *Journal of Peace Research* 49, no. 1 (January 2012): 211–25, https://doi.org/10.1177/0022343311427066.

LITERATURE ON CAMBODIA

There is relatively little literature on climate change and conflict in Cambodia, despite its high vulnerability to climate change. Ratner et al. found that most conflicts in the Tonlé Sap Lake area were due to competition related to overfishing, including conflict between large and small-scale fishers or between villages. More recently, however, different types of conflict have emerged. This includes competition over water, infrastructure, land use, and biodiversity conservation. They found three key areas of conflict: (1) illegal fishing, (2) clearance of flooded forest for agriculture, and (3) conflict between fishers and rice farmers over water and land use.

Hunsberger et al. found responses to climate change actually created land conflicts in Cambodia.[45] Demand for biofuels and climate-resilient irrigation infrastructure reshaped social and ecological dynamics and changed patterns of land access. In many cases, these projects entered land already affected by concessions and past conflict, further disenfranchising rural citizens. Additionally, there has been growing concern over upstream hydropower development in Cambodia and its effect on the Mekong River, although any linkages to conflict have yet to be investigated.[46] There were previous protests over a proposed upstream dam in Lao, and Cambodian civil society has been outspoken in its opposition to similar damming projects.[47]

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[45] Carol Hunsberger, Courtney Work, and Roman Herre, "Linking Climate Change Strategies and Land Conflicts in Cambodia: Evidence from the Greater Aural Region," *World Development* 108 (August 2018): 309–20, https://doi.org/10.1016/j.worlddev.2018.02.008.

[46] Asia Times, "Asia Times | Mekong River Dying a Slow but Certain Death | Article," Asia Times, accessed December 8, 2019, https://www.asiatimes.com/2019/12/article/mekong-river-dying-a-slow-but-certain-death/.

[47] Rod Harbinson, "Cambodian Dam Proceeds despite Opposition over Fish, Ousted Villagers," Mongabay Environmental News, 2015, https://news.mongabay.com/2015/08/cambodian-dam-proceeds-despite-opposition-over-effects-on-fish-ousted-villagers/.

"Cambodian Villagers Protest Controversial Laos Dam - Reuters," accessed December 8, 2019, https://www.reuters.com/article/us-cambodia-laos/cambodian-villagers-protest-controversial-laos-dam-idUSBRE85S0FX20120629.

Jacobson et al. found migration occurs in up to 45% of households in northwestern Cambodia, about half of which is climate-related.[48] They found migration can cause labor shortages and welfare issues but may not necessarily improve food security. While they did not draw any conclusions about conflict, the study found migration is maladaptive over the long term, creating a climate-induced poverty trap. Other research has also found that Cambodians frequently migrate to find work, particularly to the border with Thailand.[49] Internal migration is far greater in scale than external migration - nearly one quarter of the Cambodian population changed their location of residence in 2013.[50] Storms near the Tonlé Sap Lake have also resulted in large migration, and surrounding provinces are likely to see future outflow due to climate change.[51]

Bylander found that village reports of flood, drought, and rainfall deviations were associated with household out-migration in Cambodia.[52] The report found associations between international migration and reported drought and poor rainfall during the previous year. The study found no association between reports of flooding and international migration. It should be noted that the researcher controlled for broad differences between villages but concluded that the evidence was not strong enough to suggest causal relationships between drought and migration. Finally, the study found that households in areas with nongovernmental organization agriculture programs were less likely to have migrant household members, suggesting potential policy responses.

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[48] Chris Jacobson et al., "When Is Migration a Maladaptive Response to Climate Change?," *Regional Environmental Change* 19, no. 1 (January 2019): 101–12, https://doi.org/10.1007/s10113-018-1387-6.
[49] Kimchoy Phong, Federico Barreras, and Javier Sola, "Internal Migration Patterns and Practices of Low-Skilled and Unskilled Workers in Cambodia" (Open Institute, September 2016).
[50] UNDP, UNESCO, and UN Habitat, "Overview of Internal Migration in Cambodia," n.d., https://bangkok.unesco.org/sites/default/files/assets/article/Social%20and%20Human%20Sciences/publications/Policy-brief-internal-migration-cambodia.pdf.
[51] UNDP, UNESCO, and UN Habitat.
[52] Maryann Bylander, "Cambodian Migration to Thailand: The Role of Environmental Shocks and Stress" (Global Knowledge Partnership on Migration and Development, January 2016).

Chapter 3: Methodology

Despite its high exposure, limited quantitative research has been done on the security implications of climate change in Cambodia. Because of the country's high dependence on agriculture and low adaptive capacity, conflict is most likely to occur due to agricultural loss and subsequent migration. These are driven by changes in water availability. However, Cambodia has experienced a decline in conflict incidence over the past several decades, likely due to its repressive government, and finding a definitive connection between migration and conflict is beyond the scope of this research.

STUDY AREA

Figure 1: Provinces in Cambodia

The analysis focuses on Cambodia. Measures for preconditions, climate, and migration were explored country-wide. The provinces of Cambodia are shown in Figure 1. Provinces in Cambodia have a number of irregular spellings in different publications. For the sake of this research, they have been normalized to the spellings in Appendix A.

THEORETICAL FRAMEWORK

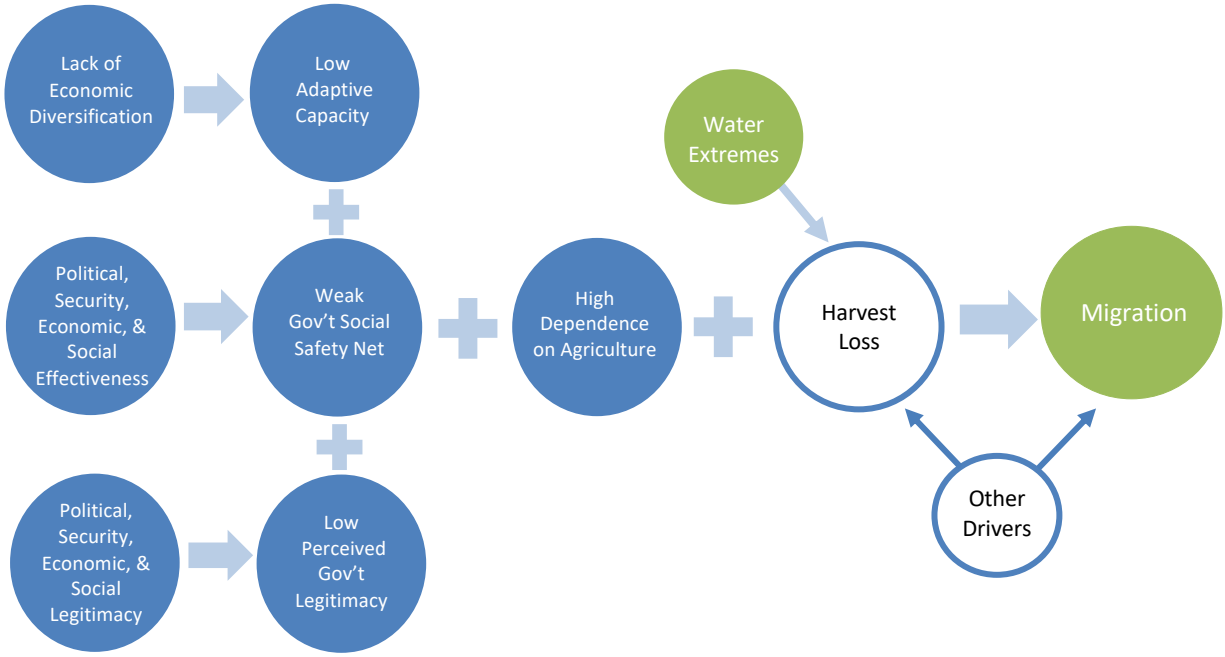

Figure 2: Theoretical Framework

The researcher developed the above theoretical framework for the purpose of this study. This research focuses on water and extremes and migration, indicated in the solid green circles. It discusses topics in the solid blue circles but does not analyze them in-depth. The open blue circles are beyond the scope of this research. While food price spikes are an interesting source of conflict in the literature, they primarily affect urban democratic populations – as Hendrix and Haggard found, autocratic governments often employ

methods to mitigate food price spikes in urban centers.[53] Cambodia is still highly rural and authoritarian, so harvest losses and resulting migration pose a more salient security risk.

The framework has three preconditions that are necessary but not sufficient for migration to occur due to agricultural losses: low adaptive capacity of the population, weak government social safety nets, and low perceptions of the government's legitimacy. Combined with a high dependence on agriculture, these factors leave Cambodia vulnerable to climate-related security risks. In addition to those preconditions, a climate-related event involving extreme water abundance or scarcity must occur, leading to an increase in harvest losses and a corresponding increase in the odds of migration.

Changes in the onset, duration, or intensity of the monsoon can have drastic consequences for smallholder farmers in rural Cambodia. There is relatively little technological innovation in Cambodia, and most agriculture relies on traditional wet-rice methods. These are highly dependent on the monsoonal floods, especially the flood-pulse system in the Tonlé Sap area. Excessive flooding can cause rice crops to rot and damage vegetable harvests while drought prevents farmers from planting in the first place or produces meager to no harvest. Drought also increases the risk in northwestern Cambodia, which is typically more arid than the wetter Tonlé Sap area.

Only 23 percent of Cambodia's GDP comes from agriculture, while 67 percent of the population is involved in agriculture in some capacity, indicating that many Cambodians are subsistence farmers.[54] This high dependence on agriculture means that a large number of citizens' livelihoods are bound up in farming. Climate shocks are more likely to result in widespread reductions in income and high levels of food insecurity.[55]

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[53] Hendrix and Haggard, "Global Food Prices, Regime Type, and Urban Unrest in the Developing World."
[54] "The World Bank in Cambodia," September 25, 2019.
[55] Joshua Busby and Nina von Uexkull, "Climate Shocks and Humanitarian Crises," September 25, 2019, https://www.foreignaffairs.com/articles/world/2018-11-29/climate-shocks-and-humanitarian-crises.

Qualitative data suggest that harvest losses can lead rural populations to migrate for work which stresses finite government resources and ethnic fissure lines, leading to conflict. There is a growing body of research on climate migration, particularly in Southeast Asia, and so an analysis will be completed along with suggestions for future research.

DATA SOURCES

Preconditions

All three preconditions are indicators of state fragility. Adaptive capacity is derived from household-level standards of living and wealth. This dataset comes from USAID's Demographic and Health Surveys (DHS).[56] The data were collected at a household level and contain measures for province (SHPROV) and rural vs. urban (HV025), which enables spatial analysis. This is important for identifying which provinces are at greatest risk. Data measures include whether a household has electricity (HV206), the number of hectares of agricultural land owned (HV245), whether the household owns livestock (HV246), whether any member of the household has a bank account (HV247), and a relative wealth index (HV270). The relative wealth index is a composite measure of a household's cumulative living standard compared to living standards in the rest of the country.

Government social safety net data are derived from the political, security, economic, and social effectiveness of the government. This includes components such as the quality of public service, presence of existing displaced populations, infant mortality rate, and poverty headcount, among others (Table 1). Government legitimacy comes from the political, security, economic, and social legitimacy of the government. These data include political participation, state use of political terror, control of corruption, and life

[56] ICF, "Demographic and Health Surveys (Various) [Dataset]. KHHR42DT, KHPR51FL, KHHR61DT, and KHHR73DT." (Rockville, MD: Funded by USAID, 1998-2014).

expectancy (Table 1). The measures for government effectiveness and legitimacy are obtained from Kishi and Linke, 2016.[57] The data is not disaggregated by province, but still offers an examination of the preconditions necessary for migration.

Type of Indicator	Government Social Safety Net (Effectiveness)	Government Legitimacy
Political	Quality of public service # of successful coups d'état in last 5 years Gov't tax revenue as a percent of GDP	Competitiveness of political participation Citizen participation in selecting government Asylum requests as percent of population
Security	Intensity of ongoing armed conflict Size of displaced population Proportion of country affected by conflict	State use of political terror Presence of militant groups against the state # of rivaling military organizations
Economic	GDP per capita Poverty headcount ratio Primary commodity exports as percent of total	Control of corruption Rule of law and property rights protection # of days to start a business
Social	Infant mortality rate Child immunization rates % of population w/ access to improved water source	Military expenditures as percent of GDP Percent of parliamentary seats held by women Life expectancy at birth

Table 1: Indicators Used to Asses State Fragility[58]

Finally, the theoretical framework requires a high dependence on agriculture. Data on agriculture is derived from the Cambodian National Institute of Statistics' (NIS) intercensal population survey. The format of Cambodian census data is inconsistent across years and publications, but a useable data file containing the employed population by occupation for 2013 was obtained from the CensusInfo Static Data Portal on the NIS

[57] Roudbeh Kishi and Andrew Linke, "Global Fragility Dataset," 2016.
[58] Data from Ashley Moran et al., "The Intersection of Global Fragility and Climate Risks" (USAID, September 2018).

webpage.[59] This was the only publicly available data that was disaggregated by province. The data provide information on the total number of people employed in skilled agriculture, fishery, and forestry. This was divided by the sum of all occupations to produce a percent of the total workers employed in agriculture.

The primary crop in Cambodia is rice, and an additional dataset was used to identify critical agricultural production regions. The International Food Policy Research Institute's Spatial Production Allocation Model (SPAM) estimates crop distribution within subnational grid cells.[60] The dataset uses production statistics, land use data, and satellite imagery to provide information about the spatial distribution of crops. The data are disaggregated spatially and by crop. For this research, the raster data for rice production were clipped to the country extent to provide a measure of the land under production.

Climate

Moran et al. identified Cambodia as one of 15 states in the highest climate exposure and state fragility categories.[61] Cambodia is vulnerable to climate effects through several climate hazards, including rising sea level infringing on the Mekong Delta, flood risks along vulnerable river and lake environments, potential for drought in water-dependent areas, and the conflation of these risks in population-dense areas (Table 2). Climate hazards expose large portions of the population and territory, which puts human health at risk and narrows potential livelihoods. Hazard exposure can also place extreme stress on limited state resources and capacity.

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[59] "CensusInfo Static Page," National Institute of Statistics, 2013, http://nis.gov.kh/nis/CensusInfo2.0/index.htm.
[60] "Globally Spatially-Disaggregated Crop Production Statistics Data for 2010 Version 1.1" (International Food Policy Research Institute, 2019).
[61] Moran et al., "The Intersection of Global Fragility and Climate Risks."

Hazard	Exposure in Cambodia
Low elevation coastal zone[62]	Cambodia has low elevation across its coastal territory to the southwest in Koh Kong, Preah Sihanouk, Kampot, and Kep provinces. There is also low elevation along the Mekong River in Takeo, Prey Veng, Kandal, and Svay Rieng provinces, although it is limited to low-lying delta areas. Low-lying areas also line the Tonlé Sap River up to the Tonlé Sap Lake, affecting the eastern corner of Battambang province and southwestern corner of Siem Reap province. These areas are exposed to future sea level rise and associated flooding, storm surge, and saltwater intrusion. Sea level rise may also exacerbate monsoon season flooding, extending flood impacts further into the country and making valuable land unsuitable for agriculture.
Cyclones[63]	Cambodia is not subject to cyclone risk.
Floods[63]	Cambodia is already flood-prone due to the seasonal monsoon flooding. This area is along the Mekong River, Tonlé Sap River, and Tonlé Sap Lake. During the wet season, water flows north through the Tonlé Sap River into the Tonlé Sap Lake, which expands and floods the surrounding area. The river flows back south during the dry season, creating an annual pattern of inundation. Most agriculture is dependent on the seasonal flooding and the flood-pulse system. Increased drought and/or sea level rise could change this flood pattern.
Rainfall anomalies[64]	Drought anomalies are predicted along the southeastern and northeastern sections of the country, according to some analyses. This will impact the already-vulnerable Mekong Delta and surrounding regions which are dependent on rainfall for agriculture.
Chronic aridity[64]	Cambodia has moderate chronic aridity throughout the country.
Wildfires[63]	There is higher wildfire risk in the northeast quadrant of the country along the border with Vietnam in Mondul Kiri province.

Table 2: Indicators Used to Assess Climate Exposure[65]

[62] Viewfinder Panoramas, "Digital Elevation Data," n.d., http://viewfinderpanoramas.org/dem3.html.
[63] UNEP/GRID-Europe, "Global Risk Data Platform," accessed May 30, 2019, https://preview.grid.unep.ch/index.php?preview=data&lang=eng.
[64] Udo Schneider et al., "GPCC Full Data Reanalysis Version 7.0 at 0.5°: Monthly Land-Surface Precipitation from Rain-Gauges Built on GTS-Based and Historic Data: Gridded Monthly Totals" (Global Precipitation Climatology Centre (GPCC) at Deutscher Wetterdienst, 2015), https://doi.org/10.5676/dwd_gpcc/fd_m_v7_050.
[65] Data from Moran et al., "The Intersection of Global Fragility and Climate Risks."

The country is exposed to high risk for flooding and droughts, increased extreme events, and decreased agricultural production.[66] While the overall population density is not high, the vast majority of people are concentrated in Phnom Penh, at an elevation of 39 feet and sits at the junction of the Mekong and Tonlé Sap Rivers, making it vulnerable to sea level rise and rainfall variability. Forty-five percent of the population (6.7 million people) reside in high exposure areas and about 20% of the population (3 million people) reside in very high exposure areas.[67] An estimated 83% (12.5 million people) of the population faces above average hazard exposure. Forty-four percent (6.6 million) are more than 1 standard deviation above the mean regional exposure score and 16% are more than 2 standard deviations above.[68]

Given Cambodia's high dependence on agriculture and vulnerability to rainfall anomalies, precipitation was chosen as the best proxy to understand climate trends over space and time. This research uses the Global Precipitation Climatology Project (GPCP) Version 2.3 as a measure for precipitation.[69] This dataset was formatted to include over 54,000 monthly observations locations from 2000 to 2019. The data were modified to exclude 2019 due to incomplete data for the year and to exclude latitude and longitude points over the Tonlé Sap Lake area which had no observations. The GPCP dataset integrates various satellite data with data from rain gauge stations to estimate monthly rainfall on a 2.5-degree global grid.

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[66] O Hoegh-Guldberg et al., "Impacts of 1.5 C Global Warming on Natural and Human Systems," in *Global Warming of 1.5 C: An IPCC Special Report on the Impacts of Global Warming of 1.5 C above Pre-Industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty* (Geneva, Switzerland, 2018).

[67] Moran et al., "The Intersection of Global Fragility and Climate Risks."

[68] Juhi Amodwala, "Cambodia," Country Mini-Brief (Strauss Center Brumley Next Generation Fellows Program, April 2018).

[69] Robert Adler et al., "The Version 2.3 Global Precipitation Climatology Project (GPCP) Monthly Precipitation Analysis (1979-Present)," n.d.

Figure 3 shows the distribution of all precipitation observations between 2000 and 2018 for each latitude and longitude point. The distribution of total observations is polynomial and thus cannot be analyzed using traditional parametric models. Parametric modelling methods, such as linear regression, require certain distributions and known parameters. The distribution is also bimodal, with one mode around 0 mm during the dry season and one around 250mm during the wet season.

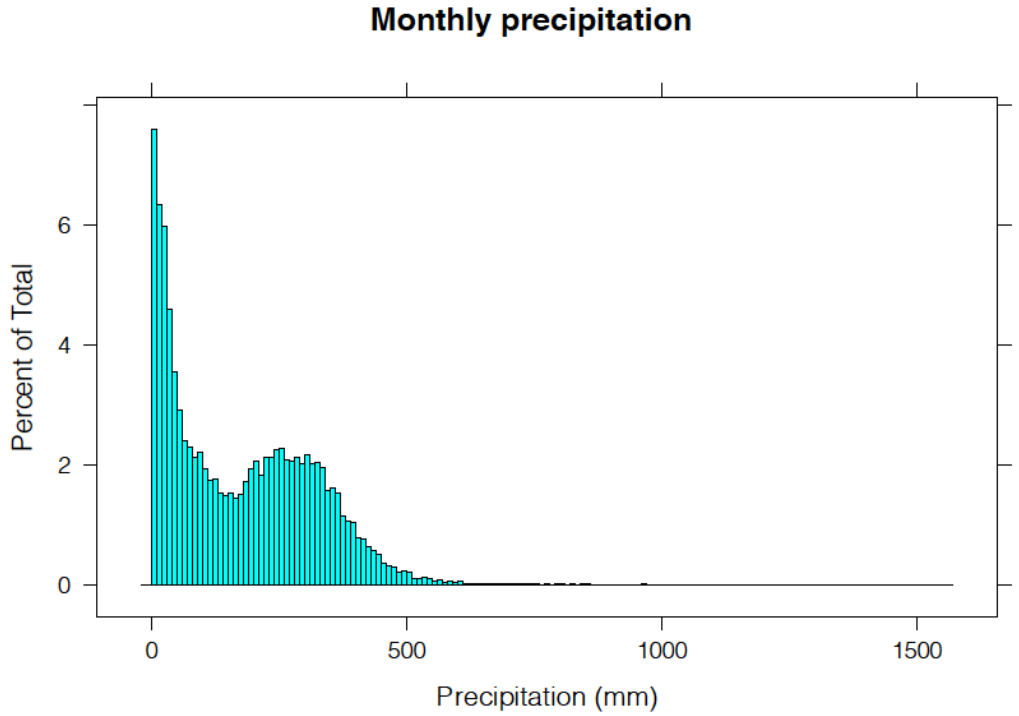

Figure 3: Distribution of Precipitation Observations[70]

Figure 4 shows the distribution of yearly precipitation means which were calculated by averaging monthly precipitation data from January to December annually for each latitude and longitude pair. The distribution of yearly precipitation means follows a Gaussian distribution with a long right tail. Figure 5 shows the measures for mean and

[70] Data from Adler et al.

central tendency. The data have a mean of 176.51 and median of 172.26, supporting the conclusion that the data is right-skewed. The standard deviation is 41.58, indicating some variation between years.

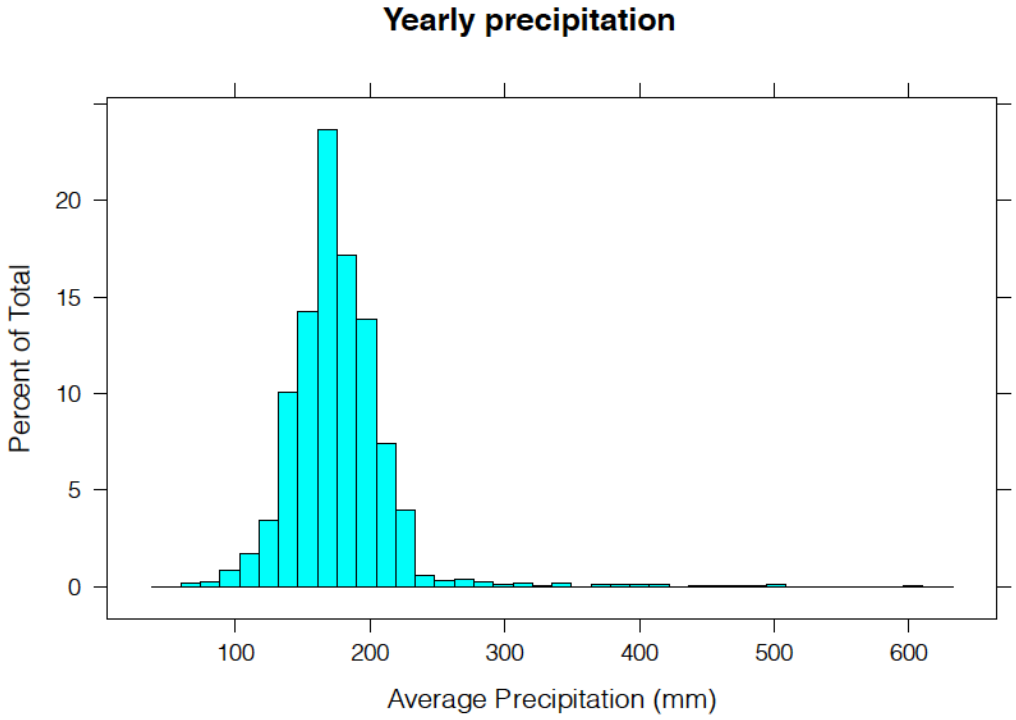

Figure 4: Distribution of Yearly Precipitation Means[71]

nbr.val	nbr.null	nbr.na	min	max	range	sum	median
4370.00	0.00	0.00	48.59	624.81	576.22	771338.32	172.26
mean	SE.mean	CI.mean.0.95	var	std.dev	coef.var		
176.51	0.63	1.23	1729.24	41.58	0.24		

Figure 5: Measures of Mean and Central Tendency for Yearly Means[71]

While the distribution of yearly means is normal, examining them over time yields an interesting pattern (Figure 6). Each dot represents a yearly mean at a single latitude-longitude point. The y-axis is the value of the yearly mean, in mm. The x-axis is the year.

[71] Data from Adler et al.

While there has been some oscillation over time, the means for 2000-2015 are tightly clustered while the means for 2016-2018 are widely dispersed. The 2016-2018 dispersion is greater for large means, but still exists for smaller ones.

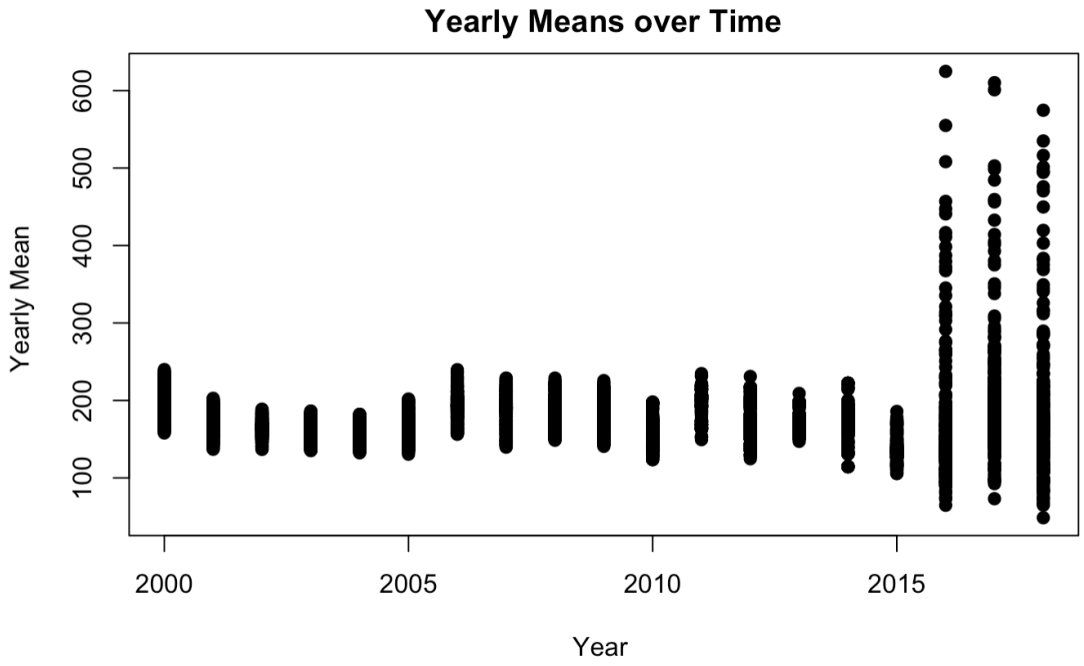

Figure 6: Scatterplot of Yearly Means over Time[72]

The measures of dispersion and central tendency support the visual results from the scatterplot (Figures 7 and 8). The data for 2000-2015 have a mean of 174.33 and median of 172.54, indicating a slight right skew. The standard deviation is 24.23, indicating that the means are tightly clustered. However, the data for 2016-2018 differ – the mean is 188.13 and the median is 169.64, indicating a significant right skew and higher mean. The standard deviation is 87.57, indicating that the data are far more dispersed during those years than the previous 15 years.

[72] Data from Adler et al.

nbr.val	nbr.null	nbr.na	min	max	range	sum	median
3680.00	0.00	0.00	105.63	239.86	134.23	641528.36	172.54
mean	SE.mean	CI.mean.0.95	var	std.dev	coef.var		
174.33	0.40	0.78	587.33	24.23	0.14		

Figure 7: Measures of Dispersion and Central Tendency for 2000-2015[73]

nbr.val	nbr.null	nbr.na	min	max	range	sum	median
690.00	0.00	0.00	48.59	624.81	576.22	129809.96	169.65
mean	SE.mean	CI.mean.0.95	var	std.dev	coef.var		
188.13	3.33	6.55	7668.49	87.57	0.47		

Figure 8: Measures of Dispersion and Central Tendency for 2016-2018[73]

Migration

Migration data were parsed together from multiple data sources including qualitative and quantitative data. The primary sources were focus group interviews, reports, and existing studies.

The focus group interviews were conducted in January 2019 in Battambang province by the researcher in order to elucidate migration and security trends. They were conducted with the help of a translator from a local development non-governmental organization called Aphivat Strey. Aphivat Strey works with the Cambodia Development Resources Institute (CDRI) to implement climate resiliency and poverty reduction development projects. The survey consisted of 35 questions divided into segments on climate change, adaptation, and security risks (Appendix B). The researcher interviewed 24 residents in three focus groups over the course of two days. Each focus group took approximately three hours. This research did not require Institutional Review Board (IRB) approval (Appendix C). The focus groups will be elaborated on in the qualitative analysis and results sections.

[73] Data from Adler et al.

There is some literature on migration in Cambodia, although the majority of it consists of research reports rather than scientific studies. These primarily come from the International Organization for Migration, USAID, the United Nations Department of Economic and Social Affairs, the World Bank, OECD, and other partner organizations. However, the majority of these sources only had country-level data. A critical source of quantitative analysis came from a 2016 study by Maryann Bylander on Cambodian migration to Thailand.[74] This research uses these reports to construct an assessment of the existing patterns of migration in Cambodia and how those patterns are related to climate effects.

QUALITATIVE ANALYSIS

A mixed analysis was completed for the theoretical framework's preconditions: adaptive capacity, government social safety net, and government legitimacy. The analysis used a combination of quantitative data measures examined over time, literature-based knowledge about political, social, and economic conditions, and mapping software to visualize conditions.

Adaptive capacity data came from USAID's Demographic and Health Surveys (DHS) for the years 2000, 2005, 2010, and 2014 and were analyzed in Stata.[75] Whether a household has electricity (HV206), whether the household owns livestock (HV246), whether the any member of the household has a bank account (HV247), and whether the household owns land usable for agriculture (HV244) were already coded in a general format where 0 indicated 'no' and 1 indicated 'yes'. The relative wealth index (HV270) was already coded where 'poorest,' 'poorer,' 'middle,' 'richer,' and 'richest' were on a

[74] Bylander, "Cambodian Migration to Thailand: The Role of Environmental Shocks and Stress."
[75] ICF, "Demographic and Health Surveys (Various) [Dataset]. KHHR42DT, KHPR51FL, KHHR61DT, and KHHR73DT." (Rockville, MD: Funded by USAID, 1998-2014).

scale from 1 to 5, respectively. The summary of each variable for each year was tabulated by province in Stata, producing a table with the mean, standard deviation, and count of the respective variable for each province.

The correlation between each variable was analyzed to determine which, if any, were redundant and already incorporated in the relative wealth index measure (Figure 9). Access to electricity and possession of livestock were both highly correlated, although in different directions. Access to a bank account was moderately correlated but was lacking data from 2005. Because the relative wealth index includes components such as ownership of certain assets, materials used for construction, and access to water and other facilities, the highly correlated variables were removed.

	hv245_ag_land	*hv270_wealth_index*
hv245_ag_land	1	
hv270_wealth_index	0.11539418	1

	hv247_bank	*hv270_wealth_index*
hv247_bank	1	
hv270_wealth_index	0.496622012	1

	hv246_livestock	*hv270_wealth_index*
hv246_livestock	1	
hv270_wealth_index	-0.827747132	1

	hv206_Electricity	*hv270_wealth_index*
hv206_Electricity	1	
hv270_wealth_index	0.791647984	1

Figure 9: Correlation of DHS Variables[76]

Ultimately, only access to agricultural land was used to measure adaptative capacity. The relative wealth index separates households within the country into quintiles.

[76] Data from ICF.

Since Cambodia is a least developed country, the relative wealth is still low compared to global standard of living and the measure does not provide particularly useful information. The final variable was then analyzed in ArcGIS for trends in temporal or spatial variation.

Measures for government social safety net and government legitimacy were taken from Kishi and Linke's Global Fragility Dataset.[77] The indicators are compiled using open-source data to create a measure of state fragility, which assesses effectiveness and legitimacy in political, security, economic, and social spheres. The dataset contains indicators for each subcategory for the years 2000-2014. In order to assess overall change, the percent change was calculated for each subcategory between 2000 and 2014. Additionally, the indicators were compared to the global average to assess relative fragility.

The indicators for government social safety net and legitimacy are from 2014. While the data is older than preferred, this was found acceptable for a number of reasons. First, the data are used to establish the preconditions rather than the full analysis. Second, the data provide a comprehensive index that is difficult to find elsewhere. Additionally, updating the data is also not feasible. There are 12 indicators that make up each index. While some of those indicators have updated data, some of them do not. Additionally, the process used to make each index is not necessarily replicable within the scope of this research. Finally, the data have likely not changed meaningfully given Cambodia's repressive political system and continued reliance on foreign aid. The details of each indicator are analyzed in the results section.

Following the analysis of climate data, described in the next section, a mixed analysis of the migration data was completed. This had two components: a series of focus groups conducted by the researcher and an analysis based on existing reports. The focus

[77] Moran et al., "The Intersection of Global Fragility and Climate Risks."

groups were conducted prior to the climate analysis to elucidate trends and concerns of community members about climate risks and exposure. The surveys were conducted in January of 2019 and had a set of 35 questions divided in three segments: climate change, adaptation, and security concerns (Appendix B). The questions were developed by the researcher and edited and translated by a project manager at Aphivat Strey.

Three focus groups were conducted in communes in Battambang province with the researcher, project manager (who acted as a translator), and group members. Battambang is in Northwestern Cambodia and was chosen for its proximity to the Thai border and Tonlé Sap Lake. It was also chosen for convenience due to the presence of English-speaking research and development organizations. The communes were Ta Pon (January 2), Prek Luong (January 3), and Rohal Suong (January 3). All members of the focus groups were rural smallholder farmers, though some held additional jobs at the local markets. The focus groups at Ta Pon and Prek Luong consisted solely of female members of Aphivat Strey's women's empowerment program. The focus group at Rohal Suong was a mixed-gender group of smallholder farmers from a climate-smart village program implemented by CDRI and the Consultative Group for International Agricultural Research (CGIAR).

The female focus groups consisted of 10 members while the climate-smart group consisted of 4 members. The members of the groups had above-average knowledge of climate change and its risks. Each focus group survey took approximately three hours with the help of a guide and translator. Questions were asked sequentially with the help of the translator, and responses were translated and recorded on paper. Following the interviews, the researcher transcribed the notes on Microsoft OneDrive and added a summary of the group interactions. The objective of the focus groups was to gather qualitative data on community-level views on climate change, household adaptive capacity, and potential security risks.

Additional data were acquired from research reports and scientific studies. The information in the reports was used to create a holistic picture of past migration trends in Cambodia as well as to predict future trends and factors motivating migration. A number of the reports directly assessed the relationship between climate change and migration.

QUANTITATIVE ANALYSIS

A quantitative analysis was completed for the precipitation data to elucidate spatiotemporal trends. Given that the distribution of all observations follows a polynomial pattern, parametric modeling such as regression analysis is not the best approach. Additionally, the data exhibits significant spatial variation. A regression of precipitation on time would be inappropriate given the extensive country-wide variation – any such model would obscure spatial variation and fail to adequately assess temporal variation. Even after aggregating the data by year, a regression of yearly means on time would still be inappropriate given the extensive variation in means as shown in Figure 6. In order to adequately assess variation, a regression analysis would have to regress each individual latitude-longitude point on time, which would be time-intensive. Additionally, an analysis of z-scores that compared each individual observation to that month's average would be inappropriate because the assumptions underlying z tests do not hold.

In order to properly assess variation in the data across space and time, the data were analyzed using the Emerging Hot Spot Analysis (EHSA) tool on ArcGIS. The tool analyses trends in spatiotemporal high and low values. The tool first requires a 3-dimensional space-time cube which compiles the precipitation data into yearly latitude-longitude bins (Figure 10), then the EHSA tool completes two statistical analyses: (1) the Getis-Ord Gi* statistic and (2) the Mann-Kendall trend test. Both analyses evaluate spatiotemporal patterns. The analysis was completed twice: once for all data, and once for rainy season data.

To create the space-time cube, the data were added to ArcGIS as a csv file and then converted into x,y data using the data's latitude and longitudinal measures. The x,y data used a geographic coordinate system but the tool required a projected coordinate system, so the data were converted to a Web Mercator projection. The data were then entered into the Create Space Time Cube by Aggregating Points tool.[78] The tool produced a three-dimensional netCDF file that contained measures for the sum, mean, and count of all observations for each bin (Figure 10 – x is longitude, y is latitude, each time slice is one year, and the time series extends from 2000 to 2018). This method created a right-skewed normal distribution of yearly means and sums, enabling the data to be analyzed by a Getis-Ord Gi* statistic.

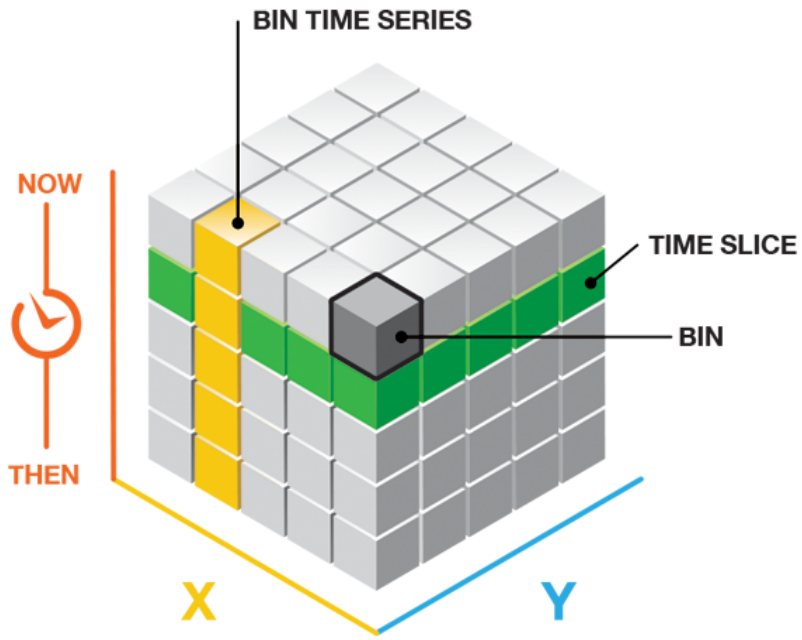

Figure 10: Visualization of a Space-Time Cube[79]

[78] To replicate this study, the data were aggregated into fishnet bins with a distance of 28,620 meters and a time step of one year.
[79] Figure from ESRI.

Once the space-time cube was created, the Emerging Hot Spot Analysis tool analyzed spatiotemporal patterns. The Getis-Ord Gi* statistic measures clustering of high or low values in a bin and its neighbors in the space-time cube.[80] Neighboring bins exist in time and space due to the three-dimensional nature of the cube. The sum of a bin and its neighbors is compared proportionally to the sum of all bins. If the observed sum is different from the expected value, and that observed sum is too large to be the result of random chance, the tool produces a statistically significant z-score. The tool produces a z-score and p-value for each bin where there is statistically significant clustering of high or low values compared to neighboring bins and to the overall country. Larger absolute value z-scores indicate more intense clustering of high or low values.

Once the Getis-Ord Gi* statistic is produced, the tool uses the Mann-Kendall statistic to test whether a statistically significant temporal monotonic trend exists in each bin's 18-year time series of z-scores.[81] A monotonic trend means that the variable consistently increases or decreases, but the scale of change does not need to be linear. Additionally, the Mann-Kendall test is a non-parametric rank order correlation test, meaning it can be used for all distributions. This is appropriate for precipitation data, which vary widely due to complex climatic systems. However, data cannot be aggregated seasonally, because the large positive value of a rainy season would oppose the small value of a dry season, resulting in a value of 0 and no pattern.

The Mann-Kendall statistic is calculated for each bin time series. Each later-measured bin is compared to all bins preceding it, resulting in a total of n(n-1)/2 possible

[80] Arthur Getis and J. K. Ord, "The Analysis of Spatial Association by Use of Distance Statistics," *Geographical Analysis* 24, no. 3 (September 3, 2010): 189–206, https://doi.org/10.1111/j.1538-4632.1992.tb00261.x.

[81] Henry B. Mann, "Nonparametric Tests Against Trend," *Econometrica* 13, no. 3 (July 1945): 245, https://doi.org/10.2307/1907187.

Maurice G. Kendall and Jean Dickinson Gibbons, *Rank Correlation Methods*, 5th ed (London: New York, NY: E. Arnold; Oxford University Press, 1990).

pairs of bins, where n is the total number of bins. For each pair of bins, a value of -1, 0, or 1 is assigned. If the z-score of the later bin is larger than the preceding, the result is a +1 (increasing trend). If the z-score of the later bin is smaller than the preceding, the result is a -1 (decreasing trend). If the later bin is no different from the preceding, the result is 0 (no trend). Each pair of bins is summed over the 18-year time series; the expected sum of the bins is zero, indicating no trend in the values over time. In this analysis, the test compares the final bin, year 2018, to all preceding bins for a single latitude-longitude point, assigning each a score of -1, 0, or 1. It then does this for 2017, and 2016, and so on. These values are summed, and a z-score and p-value are calculated for each bin time series. A positive Mann-Kendall statistic indicates an upward trend while negative values indicate a downward trend.

The cluster and trend results from the Getis-Ord Gi* and Mann-Kendall tests are then used to categorize each bin. The EHSA tool uses both the Mann-Kendall z-score and the percent of the time series that was a hot or cold spot to categorize the bin, which results in seventeen possible categories. In this analysis, a "trend" indicates a temporal change in a general direction (i.e. a drying trend) while "pattern" indicates a repeated arrangement (i.e. an oscillating pattern). The phrases "hot spot," "cold spot," and "cluster" indicate a group of similar things that are near each other. Cold spots indicate statistically significant clusters of low precipitation while hot spots indicate statistically significant clusters of high precipitation.

Essentially, the EHSA analyzed the data across the country for each individual time slice and then across time for each individual latitude-longitude point. First, it analyzed the country-wide precipitation data for a single year using the Getis-Ord Gi* test. For example, the test would first analyze the precipitation data for the year 2000, bin by bin, and determine if there were clusters of high and low precipitation in the country compared to

the expected value. Then, the Mann-Kendall test took those results and compared them for a single latitude-longitude point over time. For example, the test would analyze all years for the latitude and longitude 103.125, 13.875 to determine if there was a trend. This approach to three-dimensional data, by first analyzing horizontal slices and then analyzing vertical slices, determined whether there were any drying trends across time.

Chapter 4: Results

POLITICAL, ECONOMIC, AND SOCIAL CONDITIONS

Low Adaptive Capacity

Adaptive capacity is derived from standards of living, wealth, and assets. Cambodia is one of the United Nation's Least Developed Countries with a Human Development Index rank of 146 out of 189.[82] According to 2014 DHS data, ~ 32% of children under 5 were stunted, indicating poor nutrition.[83] About 25% of the population does not have access to improved water and 44% do not have access to improved sanitation.[84]

The country has very little income generating activities and remains highly dependent on aid from bilateral and multilateral donors. Between 2000 and 2013, Cambodia received $11.8 billion in foreign aid.[85] Development assistance constitutes 4% of GDP and 30% of the government budget.[86] At the household level, the average gross national income per capita was $1,390 USD in 2018.[87] As of 2014, 18% of the population was living below the national poverty line, and ~ 90% of the country's poor live in rural areas.[88]

Agricultural land is a key resource for rural smallholder famers due to its role as an income generator and asset. However, the DHS data for agricultural land ownership shows a disparate ownership of resources across space (Figure 11).

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[82] UNDP, "Human Development Index (HDI)," accessed May 30, 2019, http://hdr.undp.org/en/content/human-development-index-hdi.
[83] ICF, "Demographic and Health Surveys (Various) [Dataset]. KHHR42DT, KHHR51DT, KHHR61DT, and KHHR73DT."
[84] "The World Bank in Cambodia."
[85] "AidData," n.d., http://dashboard.aiddata.org/#/advanced/project-list.
[86] World Bank, "Cambodia | Data."
[87] World Bank.
[88] "The World Bank in Cambodia."

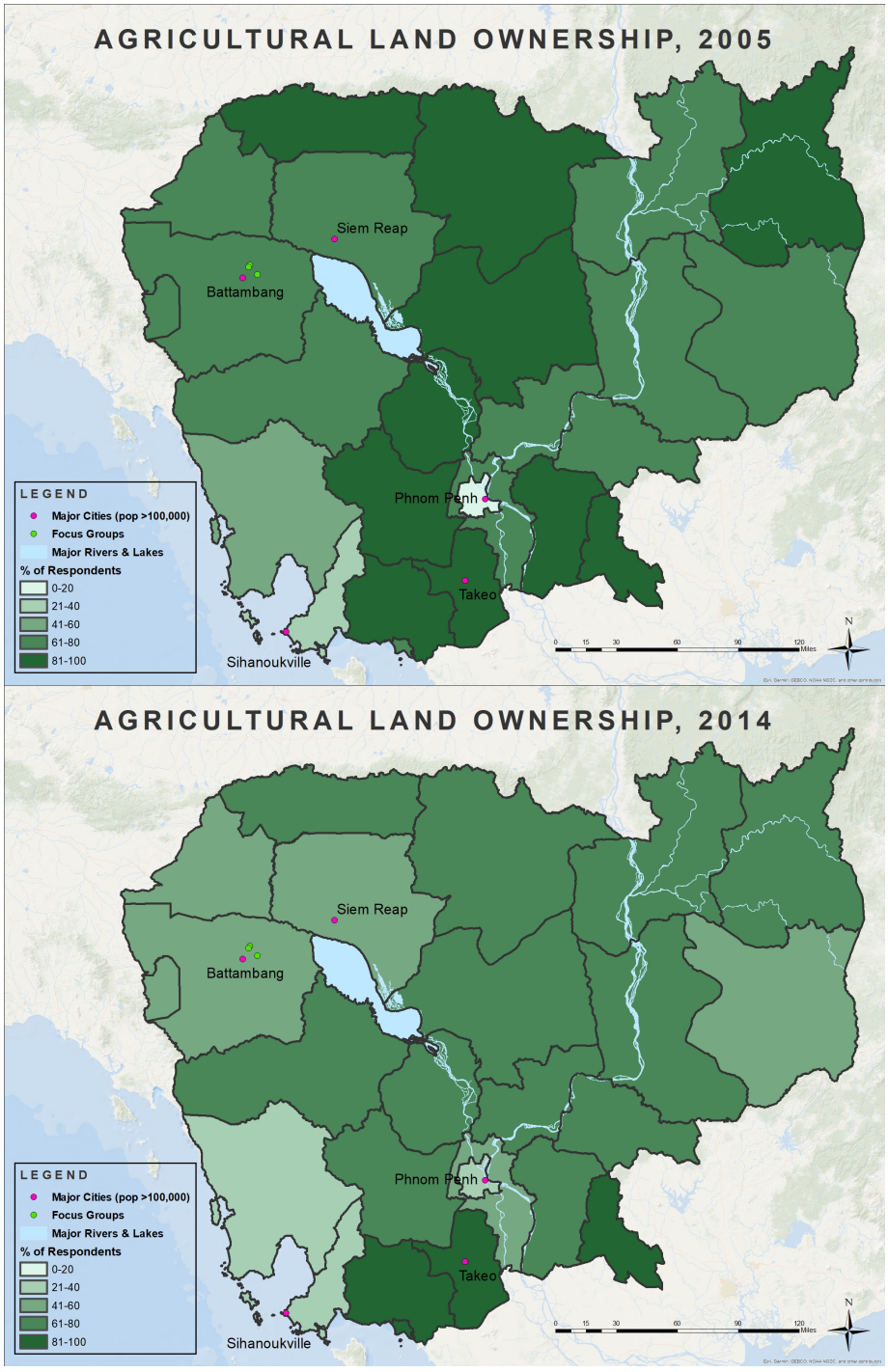

Figure 11: Percent of Population with Agricultural Land[89]

[89] Data from ICF

The spatial data in Figure 11 indicate a decline over time in the percent of respondents that own agricultural land. While the decline may indicate that people are moving to cities and finding employment in sectors other than agriculture, the trend could also be more problematic. It may be that households are losing land due to economic concessions to private agribusiness companies.[90] Households may also be unable to afford their land or must sell it to provide for their families. Regardless, the loss of land is concerning – property ownership is a critical asset for rural families and communities.

Weak Government Social Safety Net

Cambodia has made improvements in addressing government effectiveness (Table 3 – represented by declining values). Effectiveness indicators assess the capacity of government institutions and practices, including the quality of public service, proportion of country affected by conflict, poverty headcount ratio, and infant mortality rate. In particular, the country improved its *social effectiveness* scores. These scores are largely from improvements in health and wellbeing, as well as the provision of social services. Notably, all 2014 scores remain higher than the global average, indicating greater fragility.

Year	Total Effectiveness Deficits	Political Effectiveness Deficits	Security Effectiveness Deficits	Economic Effectiveness Deficits	Social Effectiveness Deficits
% change 2000-2014	⬇ 38%	⬇ 33%	-	-	⬇ 60%
2014 score	13	4	2	3	4
2000 score	21	6	2	3	10

Table 3: Government Effectiveness in Cambodia[91]

[90] "Concessions," *Open Development Cambodia (ODC)* (blog), accessed April 15, 2020, https://opendevelopmentcambodia.net/topics/concessions/.
[91] Data from Kishi and Linke, "Global Fragility Dataset."

Measures of social effectiveness include infant mortality rate, child immunization rates, and percent of population with access to improved water sources. Cambodia's improved social effectiveness stems from increased ability to deliver quality healthcare and other public goods, which has led directly to an increased vaccination rate and decreased infant mortality rate. The Ministry of Health established the National Immunization Programme in 2000, achieving significant results in the time since its initiation. Cambodia has been polio-free since 2000, achieved measles elimination in 2015, and maternal and neonatal tetanus elimination in 2015.[92] Cambodia has also achieved significant reductions in infant mortality rates. In 2000, the infant mortality rate was 79.6 per 1000 live births, far above the global average of 53.6. By 2014, that was reduced to 28.9 per 1000 live births, below the global average of 31.2.[93]

In all other effectiveness measures, however, Cambodia remains a relatively fragile state. While Cambodia's political effectiveness and social effectiveness scores have improved, they are still worse than global averages. Additionally, Cambodia had no improvement in security or economic effectiveness scores, which are also worse than global averages. Combined, these high scores indicate greater fragility. Notably, the political effectiveness score shows the greatest deviation from the global average. This is likely due to a combination of inadequate tax revenue to fund line ministries and a civil service too intertwined with the political process to provide effective government service. Consequently, the ability of the government to provide public services and resources to its citizens is worse than the global average, despite improvements from 2000 to 2014.

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[92] World Health Organization, "WPRO | Expanded Programme on Immunization," WPRO, accessed May 30, 2019, http://www.wpro.who.int/cambodia/areas/immunization/en/.
[93] World Bank, "Cambodia | Data."

Low Government Legitimacy

Cambodia experienced a rapid decrease in legitimacy between 2000 and 2014 (represented by an increase in scores). Legitimacy indicators assess the degree of public support for government institutions and officials. The majority of those legitimacy deficits lie in the *political legitimacy* and *economic legitimacy* scores (Table 4). These poor scores stem largely from the lack of political freedom and increasing control of the CPP as well as the lack of economic growth despite heavy external investment.[94] Many of these issues are rooted in Cambodia's complex history and the deepening of political control by the dominant political party.

Year	Total Legitimacy Deficits	Political Legitimacy Deficits	Security Legitimacy Deficits	Economic Legitimacy Deficits	Social Legitimacy Deficits
% change 2000-2014	↑ 39%	↑ 80%	-	↑ 33%	↑ 33%
2014 score	25	9	4	8	4
2000 score	18	5	4	6	3

Table 4: Government Legitimacy in Cambodia[95]

After escaping the brutal Khmer Rouge regime in 1979, the country built a governance system from the destruction left in the regime's wake. After signing the Paris Peace Agreement in 1991, Cambodia developed a proto-democratic system under the oversight of the United Nations. The UN lacked enforcement mechanisms, however, and the Khmer Rouge maintained political power via its seat at the UN. Eventually, current prime minister Hun Sen took office after several decades of vying for power. He has retained control since 1985, with frequent allegations of electoral fraud, corruption,

[94] Sophal Ear, *Aid Dependence in Cambodia: How Foreign Assistance Undermines Democracy* (New York: Columbia University Press, 2013).
[95] Data from Kishi and Linke, "Global Fragility Dataset."

intimidation, and elimination of opposition parties.[96] Hun Sen is one of the world's longest-serving prime ministers.

Hun Sen and his political party, the Cambodia Peoples' Party (CPP) has incredible reach and power across the country. Most villages and communes have a CPP office or two, even in remote areas. CPP officials work with village leaders to manage and verify elections, increasing the reach and power of the party to local-level elections and processes. The CPP regularly arrests or exiles institutions, political parties, and individuals that threaten its control.

The CPP elite structure is predicated on the exchange of political privileges and backing for financial contributions and loyalty to the CPP, with CPP officials distributing opportunities for fundraising to government officials.[97] Cambodia has a strong culture of neopatrimonialism in which state officials often secure the loyalty of individuals and municipal officials through complex informal webs of patronage.[98] This system leads to wealth-accumulation networks which encourage graft and aid-dependence in the Cambodia bureaucracy. Individuals often use aid money to fund their personal lifestyles and secure loyalty from those down the network. Similarly, the loyalty of business tycoons is managed through public contracts, monopolies, and land concessions. The neopatrimonial system has created a cemented elite that control the regulatory and political system for their benefit rather than the benefit of the Cambodian people.

The CPP has implemented a number of policies to eliminate opposition and consolidate power. Following the 2003 elections, Hun Sen placed loyalists in key positions

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[96] "Cambodia: Crackdown Crushes Media, Opposition," Human Rights Watch, January 18, 2018, https://www.hrw.org/news/2018/01/18/cambodia-crackdown-crushes-media-opposition.
[97] International Institute for Asian Studies, "Politics and Society in Contemporary Cambodia," accessed May 30, 2019, https://iias.asia/the-newsletter/article/politics-society-contemporary-cambodia.
[98] Pak Kimchoeun et al., *Accountability and Neo-Patrimonialism in Cambodia: A Critical Literature Review*, Working Paper 34 (Phnom Penh: Cambodia Development Resource Institute, 2007).

and began expanding state, business, and military power and developing a patronage system. The army currently has an estimated 3000 generals (three times more than the US army), while the number of honorary titles bestowed on businessmen has increased from 20 in 2004 to 700 in 2014.[99] Key agencies, such as the Anti-Corruption Unit (ACU), operate as enforcers for the CPP and have targeted opposition leaders Sam Rainsy and Kem Sokha.[100] The killings of garment sector unionist Chea Vichea in 2004, environmentalist Chut Wutty in 2012, and government critic Kem Ley in 2016 were likely politically motivated.[101]

In 1997, the CCP passed the Law on Political Parties to manage the legality and regulation of political parties. In 2017 the CCP amended the law to pave the way for the regime to ban opposition leaders for five years.[102] The CPP also periodically amends and passes legislation restricting civil rights such as press freedom and freedom of movement. This consolidation of power and crackdown on dissent has coincided with fewer protests and lower conflict, largely due to the tightening of restrictions on peaceful protests. This has allowed Hun Sen to retain power unchallenged since the 2000s and fully consolidate power in the CPP during the most recent election.

While 20 parties participated in the most recent election, the CCP banned the primary opposition party Cambodia National Rescue Party and recently formed Cambodia

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[99] Mech Dara, "Government Approves 56 Additional Generals, National, Phnom Penh Post," accessed May 30, 2019, https://www.phnompenhpost.com/national/government-approves-56-additional-generals.
Sek Odom, "As Oknha Ranks Grow, Honorific Loses Meaning," The Cambodia Daily, June 21, 2014, https://www.cambodiadaily.com/news/as-oknha-ranks-grow-honorific-loses-meaning-62057/.

[100] International Institute for Asian Studies, "Politics and Society in Contemporary Cambodia."

[101] International Institute for Asian Studies.

[102] Ben Sokhean, "Assembly Passes Amendment to Political Party Law Article 45," Phnom Penh Post, accessed May 30, 2019, https://www.phnompenhpost.com/national-politics/assembly-passes-amendment-political-party-law-article-45.

National Rescue Movement.[103] In order to prove their legitimacy, the CPP had local officials record the names of villagers that did not vote and allegedly threatened to withhold public services.[104] Without their primary opposition on the ballot, the Cambodia Peoples Party took all 125 seats of the National Assembly with a reported 83% voter turnout, further consolidating its hold on the nation.[105]

High Dependence on Agriculture

A high level of dependence on agriculture is if at least 40% of the country's population works in agriculture.[106] About 67% of Cambodia's population is involved in agriculture, meeting that threshold. However, only 23.4% of GDP comes from agriculture and it is not a significant income-generating activity.[107] Many of those involved in agriculture are poor smallholder farmers who rely on their crops for subsistence.

The distribution of agricultural involvement is not equal across the country (Figure 12). The data in the figure shows the percentage of respondents (employed persons) who are employed in agriculture. The provinces of Phnom Penh, Preah Sihanouk, Kandal, Koh Kong, Siem Reap, and Battambang are less dependent on agriculture due to the presence of a large city or other employment opportunities (usually related to coastal tourism and

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[103] Prak Chan Thul, "Cambodia's Ruling Party Won All Seats in July Vote: Election Commission," Reuters, August 15, 2018, https://www.reuters.com/article/us-cambodia-election/cambodias-ruling-party-won-all-seats-in-july-vote-election-commission-idUSKBN1L01E7.

[104] "Authorities Threaten to Withhold Public Services If Villagers Don't Vote For Cambodia's Ruling Party," Radio Free Asia, accessed May 30, 2019, https://www.rfa.org/english/news/cambodia/threats-07172018164210.html.

[105] "Hun Sen's CPP Wins All Parliamentary Seats in Cambodia Election," accessed May 29, 2019, https://www.aljazeera.com/news/2018/08/hun-sen-cpp-wins-parliamentary-seats-cambodia-election-180815135109639.html.

[106] Busby and Uexkull, "Climate Shocks and Humanitarian Crises."

Judith M. Bretthauer, "Conditions for Peace and Conflict: Applying a Fuzzy-Set Qualitative Comparative Analysis to Cases of Resource Scarcity," *Journal of Conflict Resolution* 59, no. 4 (June 2015): 593–616, https://doi.org/10.1177/0022002713516841.

[107] World Bank, "Cambodia | Data."

poorer agricultural conditions). Nearly two-thirds of the provinces have agricultural involvement rates higher than the country-wide average of 67%, indicating that the livelihoods of rural Cambodians are likely to be connected to agricultural sector.

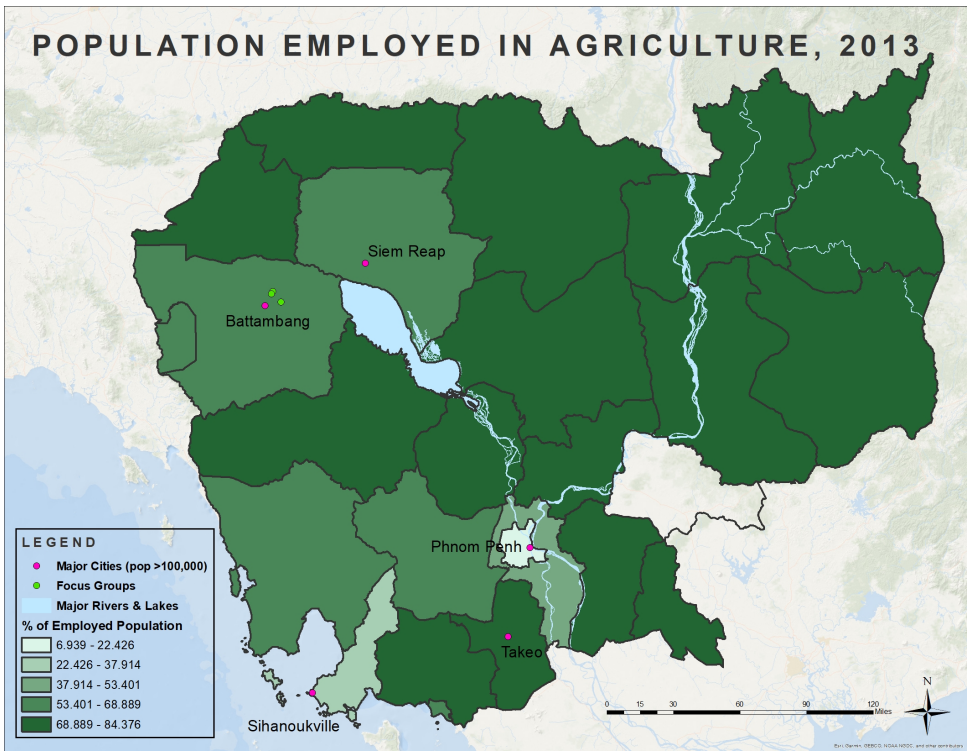


Figure 12: Percent of Employed Population in Agriculture, Forestry, and Fishing[108]

The primary crop in Cambodia is rice, although many communities also rely on vegetables, cassava, and maize production.[109] Rice production is highly susceptible to changes in rainfall because most of the country remains reliant on wet-rice agriculture and lacks irrigation systems.[110] The wet season typically lasts from June to November and

[108] Data from "Cambodia Inter-Censal Population Survey 2013: Final Report" (National Institute of Statistics, Ministry of Planning, November 2013).
[109] "Cambodia - Agricultural Sector," August 6, 2019, https://www.export.gov/apex/article2?id=Cambodia-Agricultural-Sector.
[110] "Cambodia - Agriculture, Forestry, and Fishing," Encyclopedia Britannica, accessed March 15, 2020, https://www.britannica.com/place/Cambodia.

farmers typically plant their primary crop in June-July and harvest in November-January. Farmers produce rice for household consumption and to sell at markets. Therefore, smallholder farmers are highly vulnerable to rainfall changes that affect rice production.

Certain regions of the country are better for rice agriculture due to natural topography and climate systems. These areas are clustered in two regions: around Tonlé Sap Lake, where the topography is flat and rice agriculture can use the lake's flood pulse system for water, and the Mekong River, where water is readily available (Figure 13).[111]

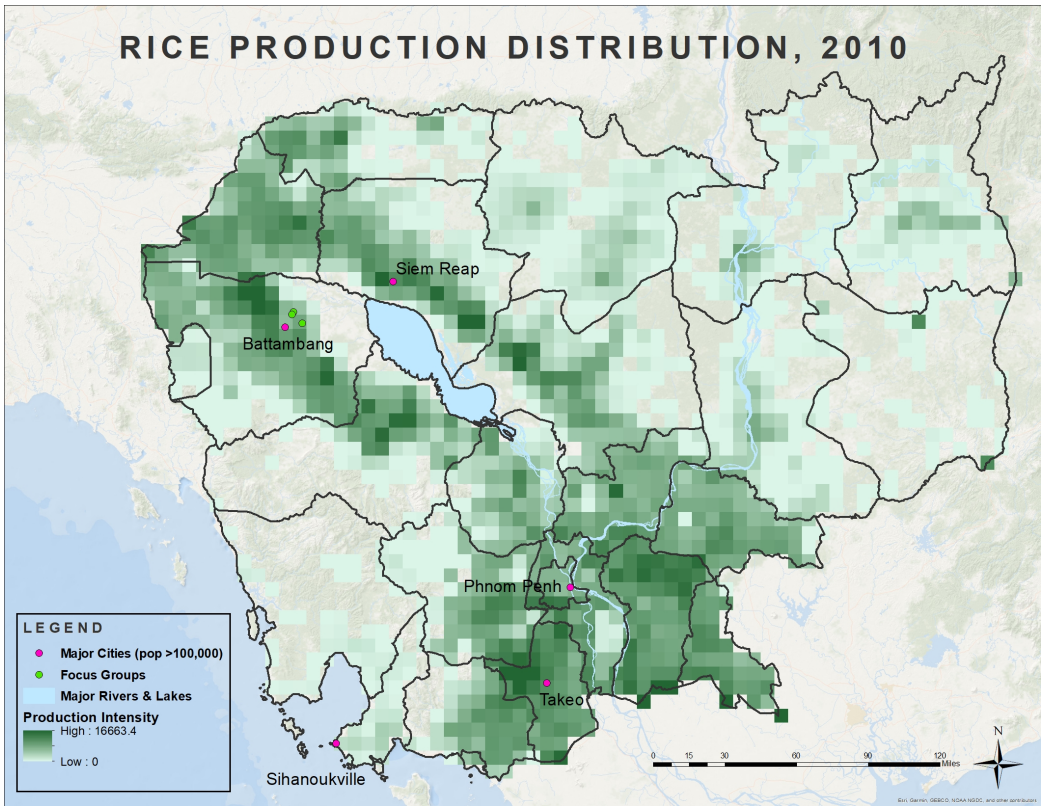


Figure 13: Spatial Distribution of Rice Production[112]

[111] Mary Beth Day et al., "Middle to Late Holocene Initiation of the Annual Flood Pulse in Tonle Sap Lake, Cambodia," *Journal of Paleolimnology* 45, no. 1 (January 2011): 85–99, https://doi.org/10.1007/s10933-010-9482-9.

[112] Data from "Globally Spatially-Disaggregated Crop Production Statistics Data for 2010 Version 1.1."

PRECIPITATION TRENDS

The Emerging Hot Spot Analysis tool produces seventeen categories covering a range of scenarios. These categories are based on the percent of time that a bin time series was a hot spot or cold spot and the Mann-Kendall z-score. In order to reduce distractions from the mapped results, all categories without results were removed. Additionally, the colors were inverted from the default output to best visualize precipitation results – red colors represent region of low precipitation, or a cold spot. Blue colors represent a region of high precipitation, or a hot spot. The categories are explained in Table 5.

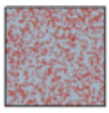
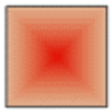
Hot Spot Pattern	Description
Consecutive Hot Spot 	A location with a single uninterrupted run of statistically significant hot spot bins in the final time-step intervals. The location has never been a statistically significant prior to the final hot spot run and less than ninety percent of all bins are statistically significant hot spots.
Sporadic Hot Spot 	A location that is an on-again then off-again hot spot. Less than ninety percent of the time-step intervals have been statistically significant hot spots and none of the time-step intervals have been statistically significant cold spots.
Oscillating Hot Spot 	A statistically significant hot spot for the final time-step interval that has a history of also being a statistically significant cold spot during a prior time step. Less than ninety percent of the time-step intervals have been statistically significant hot spots.
Consecutive Cold Spot 	A location with a single uninterrupted run of statistically significant cold spot bins in the final time-step intervals. The location has never been a statistically significant cold spot prior to the final run and less than ninety percent of all bins are statistically significant cold spots.
Intensifying Cold Spot 	A location that has been a statistically significant cold spot for ninety percent of the time-step intervals, including the final time step. In addition, the intensity of clustering of low counts in each time step is increasing overall and that increase is statistically significant.

Table 5: Hot Spot Analysis Patterns[113]

[113] "How Emerging Hot Spot Analysis Works—ArcGIS Help | Documentation," accessed February 2, 2020, https://pro.arcgis.com/en/pro-app/tool-reference/space-time-pattern-mining/learnmoreemerging.htm.

Sporadic Cold Spot 	A location that is an on-again then off-again cold spot. Less than ninety percent of the time-step intervals have been statistically significant cold spots and none of the time-step intervals have been statistically significant hot spots.
Oscillating Cold Spot 	A statistically significant cold spot for the final time-step interval that has a history of also being a statistically significant hot spot during a prior time step. Less than ninety percent of the time-step intervals have been statistically significant cold spots.
No Pattern Detected 	Does not fall into any of the hot or cold spot patterns defined above

Table 5, continued.

The data are contained in a cube similar to the example in Figure 14 (not derived from this analysis). Each latitude-longitude-year bin contains a z-score indicating whether it is a hot or cold spot. Larger absolute values indicate a greater deviation from the expected value and appear as deeper red or blue. These are then compared over time to determine the pattern and trend, as described in the methodology section.

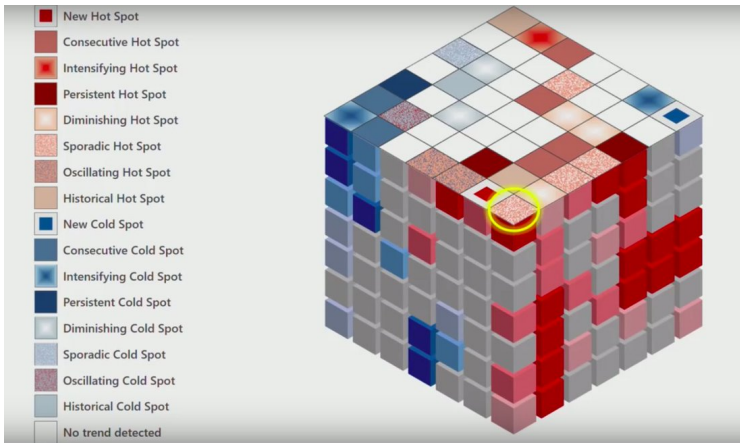


Figure 14: Space-Time Cube Representation[114]

[114] Figure from Varun Adibhatla, "Space-Time Hotspot Analysis from ESRI," Threader, accessed April 15, 2020, https://threader.app/thread/1162756909008654336.

The output map (Figure 15) shows the eight categories included in the results.[115] The analysis was completed for yearly means and rainy season means, but the output showed little variation between the two. While rice is produced more intensely in the wet season, it is a year-round crop.[116] Thus, the output map for yearly means was chosen.

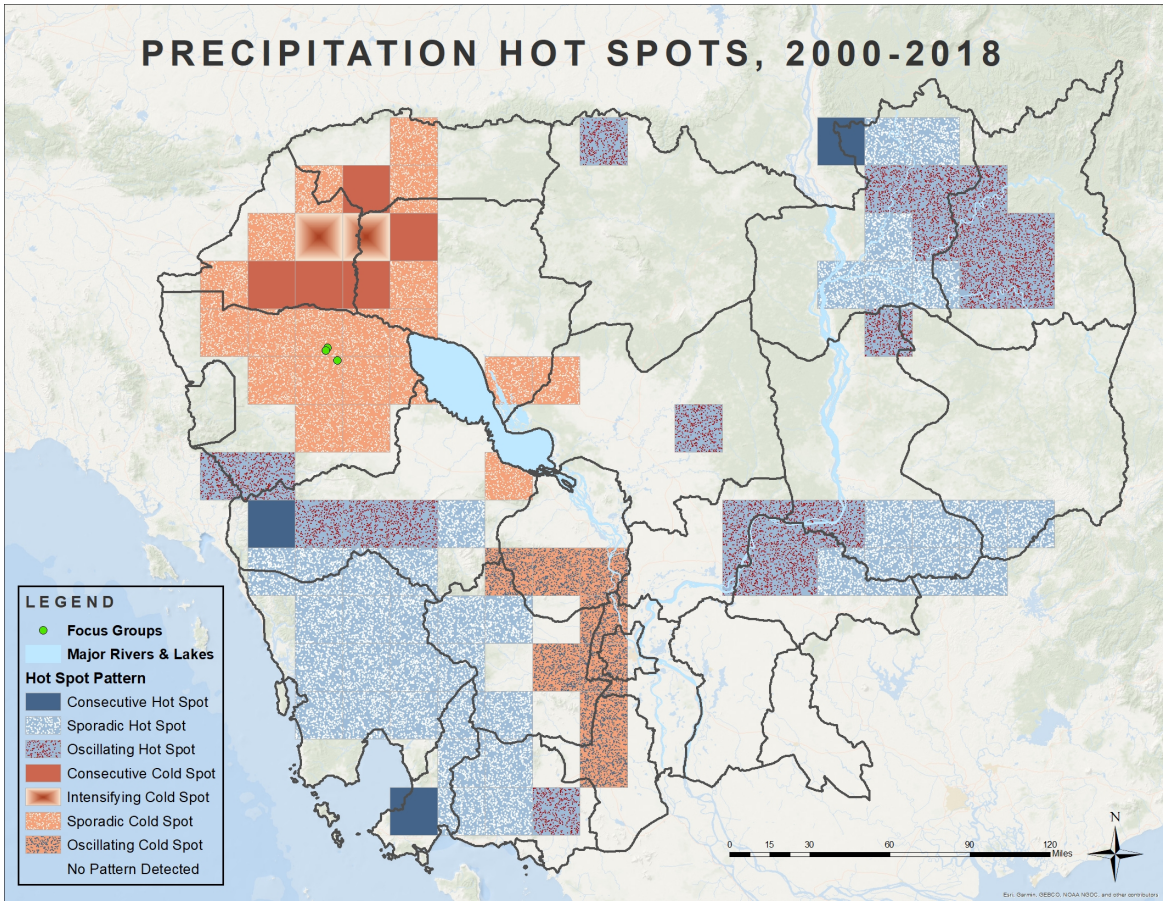


Figure 15: Emerging Hot Spot Analysis for Precipitation[117]

[115] A visualization of the hot spot results over time is available at the following link: https://youtu.be/bu8H2hzikkg

[116] "Commodity Intelligence Report," USDA Foreign Agricultural Service, 2013, https://ipad.fas.usda.gov/highlights/2013/11/Cambodia/.

[117] Data from Adler et al.

The Emerging Hot Spot Analysis (EHSA) results show significant spatial variation (Figure 15). The southwest and eastern portions of the country have experienced sporadic periods of increasing precipitation, although these results do not indicate a statistically significant trend. The northwest region has several consecutive and intensifying cold spots that are statistically significant, indicating that clusters of low precipitation in recent time periods have been the norm and have, in fact, been deepening. This is significant for agricultural losses and potential migration.

The northeast and southwest regions of the country have similar results, including sporadic hot spots, oscillating hot spots, and consecutive hot spots. This includes the provinces of Ratanak Kiri and Stung Treng in the northeast and Koh Kong, Preah Sihanouk, Kampot, Pursat, and Kampot in the southwest. The sporadic hot spots indicate on-again-off-again periods of high precipitation relative to the expected value. The oscillating hot spots indicate high precipitation in the final time-step interval and the presence of a previous cold spot. The consecutive hot spot bin indicates consecutive years of high precipitation in the final time-step. These results do not necessarily indicate an increasing trend. The Mann-Kendall z-scores for these regions are not statistically significant and the percent of time the bins were a hot spot is low. There is a similar pattern in the eastern provinces of Kratie, Tboung Khmum, Kampong Cham, and the southern portion of Mondul Kiri. While these trends are interesting, they do not indicate increasing clusters of precipitation over time.

The results for the northwest region of the country, including Battambang, Banteay Meanchey, Oddar Meanchey, Siem Reap, and some areas around Tonlé Sap Lake reveal a trend of decreasing precipitation in the region (Figure 16). The majority of the area is a sporadic cold spot, indicating on-again and off-again clusters of low precipitation. These bins were cold spots between 10% and 84% of the time, and all except one have a

statistically significant Mann-Kendall z-score, demonstrating a decreasing trend. Additionally, there is a region in Banteay Meanchey and Siem Reap provinces with consecutive and intensifying cold spots. The consecutive cold spots indicate that all the final time-step intervals are statistically significant clusters of low precipitation compared to the expected value based on country-wide temporal neighbors. These bins were cold spots 89% of the time and all have statistically significant negative Mann-Kendall z-scores, demonstrating a decreasing trend. The intensifying cold spots indicate that the majority of the time-step intervals were statistically significant clusters of low precipitation and the clustering of low counts in each time step is increasing overall. These bins were cold spots 94% of the time and all have statistically significant Mann-Kendall z-scores, demonstrating a decreasing trend in precipitation. Thus, these results show a trend of decreasing precipitation in northwest Cambodia.

Location ID	Pattern	% Cold Spot	Z-Score	P-Value
42	Intensifying Cold Spot	94.74	-2.45	0.014
41	Intensifying Cold Spot	94.74	-2.31	0.021
61	Consecutive Cold Spot	89.47	-2.45	0.014
43	Consecutive Cold Spot	89.47	-2.38	0.017
23	Consecutive Cold Spot	89.47	-2.31	0.021
60	Consecutive Cold Spot	89.47	-2.31	0.021
59	Consecutive Cold Spot	89.47	-2.24	0.025
40	Sporadic Cold Spot	84.21	-2.10	0.036
78	Sporadic Cold Spot	78.95	-2.87	0.004
22	Sporadic Cold Spot	78.95	-2.31	0.021
24	Sporadic Cold Spot	78.95	-2.10	0.036
77	Sporadic Cold Spot	78.95	-1.82	0.069
58	Sporadic Cold Spot	78.95	-1.47	0.142
79	Sporadic Cold Spot	73.68	-2.73	0.006
62	Sporadic Cold Spot	73.68	-2.59	0.010
80	Sporadic Cold Spot	68.42	-2.66	0.008
5	Sporadic Cold Spot	63.16	-3.29	0.001
81	Sporadic Cold Spot	63.16	-3.01	0.003
98	Sporadic Cold Spot	52.63	-2.52	0.012
97	Sporadic Cold Spot	52.63	-2.17	0.030
99	Sporadic Cold Spot	47.37	-2.52	0.012
117	Sporadic Cold Spot	36.84	-2.45	0.014
100	Sporadic Cold Spot	31.58	-2.45	0.014
103	Sporadic Cold Spot	26.32	-2.31	0.021
118	Sporadic Cold Spot	26.32	-2.24	0.025
102	Sporadic Cold Spot	21.05	-2.24	0.025
140	Sporadic Cold Spot	10.53	-2.10	0.036

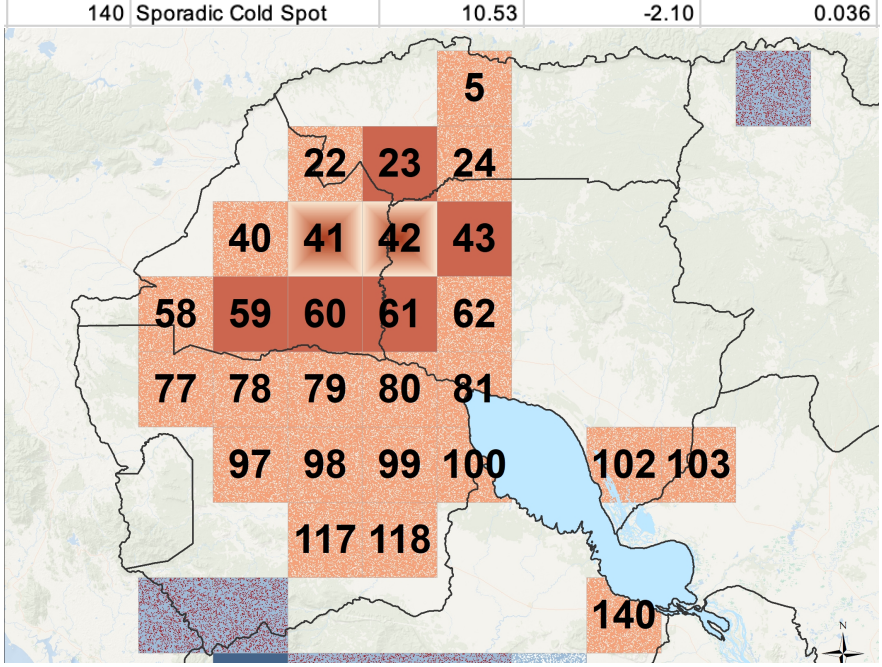


Figure 16: Statistical Results for Northwest Cambodia[118]

[118] Data from Adler et al.

When compared to rice production, the map shows the vulnerability of northwestern Cambodia (Figure 17). Regions that have more intense rice production and greater precipitation deviations are more vulnerable. In cases of excessive flooding, farmers can try to pump the water but if it stays on the fields too long, it rots the crop. However, the results did not indicate significant increases in precipitation. On the other hand, poor rainfall means that farmers are unable to plant and grow rice, or their harvests are greatly diminished. The results clearly indicate that the northwestern portion of the country is the most vulnerable to climate effects due to the strong increase in drying and heavy rice production. The region experiencing increases in precipitation, the southwest, has little rice production and thus is at lower risk. Regions around Phnom Penh and Takeo, where there is rice production along the Mekong River, are at moderate risk.

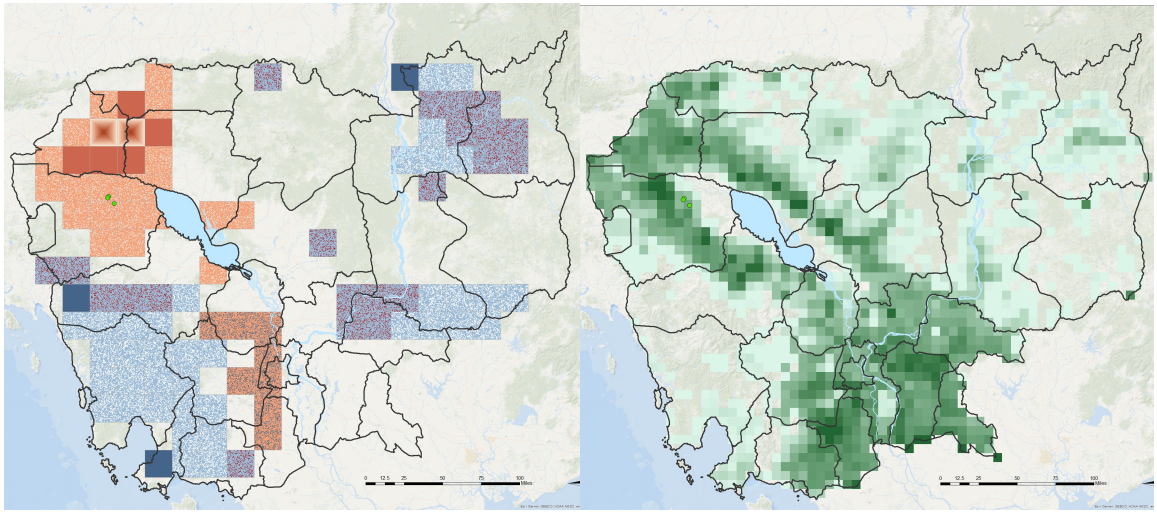


Figure 17: Agricultural Vulnerability[119]

[119] Data from Adler et al. and "Globally Spatially-Disaggregated Crop Production Statistics Data for 2010 Version 1.1"

MIGRATION TRENDS

Cambodia's migration history and patterns are heavily influenced by its political history. During the Khmer Rouge regime (1975-1979), an estimated 35-40% of the population were internally displaced, mostly through forced migration from urban centers to rural communes.[120] Following the fall of the regime at the hands of the Vietnamese army, the Khmer Rouge and Vietnamese-backed People's Republic of Kampuchea continued to struggle for control until the Paris Peace Agreement in 1991. During this time period, around 600,000 Cambodians left the county for Thailand, France, North America, Australia, New Zealand, and other ASEAN nations.[121] Following the peace agreement, the United Nations Transitional Authority in Cambodia (UNTAC) took control of the country from 1992 to 1993, and many people returned home from displaced persons camps along the Thai border.

Migration from 1993 through the early 2000s was largely internal. In 2008, 26.52% of the Cambodian population were migrants and only 2.67% of those migrants originated outside of Cambodia.[122] In urban areas, 57.93% of the population were migrants while 18.90% of the rural population were migrants, suggesting a strong rural to urban migration trend.[123] In urban areas, the majority of migrants were from rural areas, while rural migrants were often from other rural areas. 37.9% of migrants moved because their family moved, while 21.5% moved in search of employment.[124] The highest proportion of migrants during this time period were in the 20-24 and 25-29 age groups.[125]

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[120] Suzana Crassard, "Country Profile: Cambodia" (International Organization for Migration, 2009).
[121] Sarthi Acharya, "Migration Patterns in Cambodia - Causes and Consequences," 2003.
David Chandler, *A History of Cambodia.*, 4th ed. (Boulder, CO: Westview Press, 2009).
[122] "General Population Census of Cambodia 2008: National Report on Final Census Results" (National Institute of Statistics, Ministry of Planning, August 2009).
[123] "General Population Census of Cambodia 2008: National Report on Final Census Results."
[124] "General Population Census of Cambodia 2008: National Report on Final Census Results."
[125] "General Population Census of Cambodia 2008: National Report on Final Census Results."

In 2013, 28.9% of the population were migrants and 2.5% of those were from outside of Cambodia, a 2% increase in internal migrants but a negligible decrease in international migrants in the country relative to 2008.[126] Eighty-two percent of the total migrants originated in rural areas, and 67.1% of the migrants in urban areas had their previous residence in a rural area, again suggesting a strong rural to urban migration trend.[127] Of the total number of migrants, 42.2% moved because their family moved, while 21.8% moved due to marriage and 13.2% moved in search of employment.[128] The highest proportion of migrants were in the 25-29 and 30-34 age groups, indicating that migrants were older compared to 2008.

While census data provides insight into internal trends, it does not provide any information on migrants leaving Cambodia. UN data indicates that more and more Cambodians are emigrating abroad to find jobs, driven by low domestic wages and limited domestic job opportunities.[129] In 2000, the number of Cambodians overseas was only 3.7% of the population, about 450,000 people (Table 6).[130] By 2015, an estimated 1.19 million Cambodian were emigrants, constituting 7.6% of the country's population. Thailand is the most common destination for Cambodian migrants, receiving 68% in 2015. This marks a significant increase from 2000, where Thailand received only 34% of Cambodian migrants, although it was still the primary destination.

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126 "Cambodia Inter-Censal Population Survey 2013: Final Report."
127 "Cambodia Inter-Censal Population Survey 2013: Final Report."
128 "Cambodia Inter-Censal Population Survey 2013: Final Report."
129 OECD and Cambodia Development Resource Institute, *Interrelations between Public Policies, Migration and Development in Cambodia*, OECD Development Pathways (OECD, 2017), https://doi.org/10.1787/9789264273634-en.
130 OECD and Cambodia Development Resource Institute.

		2000	2015
Migrants (% out of total population)		3.7%	7.6%
Destination Countries (% of total migrants)	Thailand	34%	68%
	USA	30%	14%
	France	16%	5%
	Australia	5%	3%

Table 6: Migration Destinations from Cambodia[131]

Most international migrants are unskilled men seeking work in agriculture, fishing and fishery processing, sawmills, factories, construction, private households, or the sex trade (Table 7).[132] The majority of Cambodian migrants in Thailand are undocumented. Approximately 10% of Cambodian migrants emigrate through legal channels.[133] As of 2008, around 90% of the migrants in Thailand were irregular labor migrants.[134] These seasonal migrants are unlikely to migrate legally due to the cost and time involved. Most migrants are concentrated in the eastern half of Thailand near the Cambodian border, as most intend to return to Cambodia. However, the average stay is three years.[135]

[131] Data from "Trends in International Migrant Stock: The 2015 Revision" (United Nations, Department of Economic and Social Affairs, Population Division, 2015).
[132] Bruno Maltoni, "Impact of Remittances on Local Communities in Cambodia: The Case of Prey Veng Province" (World Bank, 2005).
[133] Max Tunon and Rim Khleang, "Cross-Border Labour Migration in Cambodia: Considerations for the National Employment Policy," Working Paper (International Labour Organization, October 2013).
[134] Bruno Maltoni, "Review of Labour Migration Dynamics in Cambodia" (International Organization for Migration, 2006).
[135] Bylander, "Cambodian Migration to Thailand: The Role of Environmental Shocks and Stress."

Industry	People	Percent of Migrants
Fisheries & related	20,989	16.8%
Farming and livestock & related	31,162	25%
Construction	32,465	26%
Mining/quarrying	61	0.1%
Wholesale and retail	4,778	3.8%
Food and beverage	4,483	3.6%
Housemaids	6,578	5.3%
Others	24,245	19.4%

Table 7: Irregular Migrants in Thailand by Sector (2009)[136]

Notably, undocumented migrant workers are enormously underestimated, and the numbers are likely far higher in reality. In 2014, more than 250,000 irregular Cambodian migrants returned home due to fear of arrest from Thai authorities.[137] In August 2017, 203,732 Cambodian irregular migrants in Thailand registered as part of a push to legitimize irregular migrants.[138] These numbers suggest a far greater presence of undocumented Cambodian migrant workers in Thailand than are reported even through survey data.

In 2014, the main migrant-sending provinces were Banteay Meanchey, Battambang, and Siem Reap, followed by Prey Veng and Takeo (Table 8).[139]

[136] Data from S Paitoonpong and Y Chalamwong, "Managing International Labor Migration in ASEAN: A Case of Thailand" (Thailand Development Research Institute, 2012), http://tdri.or.th/wp-content/uploads/2013/07/h117.pdf.
[137] "Cambodia: Thailand Worker Exodus Tops 250,000," Al Jazeera, accessed March 15, 2020, https://www.aljazeera.com/news/asia-pacific/2014/06/cambodia-thailand-worker-exodus-tops-250000-201426145249756686.html.
[138] David Sen, "200,000 Migrant Workers Register in Thailand," *Khmer Times*, August 9, 2017, http://www.khmer-timeskh.com/5077325/200000-migrant-workers-register-thailand/.
[139] Naomi Hatsukano, "Returned Migrant Workers in Cambodia: Motivations for Moving and Economic Reintegration" (Institute of Developing Economies - Japan External Trade Organization, 2019).

Province	Number of Persons
Banteay Meanchey	127,346
Battambang	84,393
Siem Reap	53,335
Prey Veng	49,648
Takeo	31,418
All others	539,937

Table 8: Emigration by Province (2014)[140]

The three largest contributors, Banteay Meanchey, Battambang, and Siem Reap, are all northwestern provinces along the border with Thailand and are reliant on agriculture. These three provinces also have the greatest drying trends (Figures 16 and 17). This suggests a link between agricultural vulnerability and migration, although statistical establishment of such a relationship is beyond the scope of this paper.

The decision to migrate is complex. Workers may move due to push factors such as poverty, lack of employment, landlessness, debt, and natural disasters. The effects of climate change may be incorporated in other factors, such as poverty and agricultural losses, driving the decisions to migrate. As climate change puts pressure on rural communities that are still heavily dependent on agriculture, however, irregular migration to Thailand may be increasing.

The focus group surveys exposed the vulnerability of locals to climate effects. The majority of participants cited either excessive flooding or not enough rain as their greatest climate concerns. In cases of excessive flooding, the focus groups said they would try to

[140] Data from Hatsukano.

pump the water but if it stayed on the fields too long, it would rot the crop. Conversely, not enough rain meant they would be unable to plant and grow rice crops. Most communities have retaining ponds that hold some water, but pumping systems are limited and water levels are typically at their lowest before the onset of the rainy season. Thus, changes in the variability of water is critically important for the success or failure of rice harvests.

Many communities also have livestock, vegetable gardens, and fish stocks. These are all used as coping mechanisms when rice crops fail. Group members said that if a rice crop failed, they would sell fish or vegetables at the market. Most families did not have any savings, and all their assets were in infrastructure and livestock. When asked what they would do if these were not enough, if a family member fell ill, or if another adverse event occurred, most community members said that a family member would have to migrate for work. All groups mentioned migration as a potential coping mechanism. They frequently mentioned cassava plantations in Thailand as a potential source of income.

A study by Bylander surveyed households with and without migrants to assess whether they had experienced poor rainfall in the previous year. Of households that sent migrants to Thailand in 2009, 50% experienced poor rainfall in 2008. (Figure 18).[141] On the contrary, only 20% of non-migrant sending households experienced poor rainfall in 2008. Of the migrant-sending households, 75% experienced differences in rainfall onset during the previous year, while only 55% of non-migrant sending households experienced differences in rainfall onset. Of households that sent migrants in 2009, 60% experienced poor distribution of rainfall during the previous year, while only 20% of the non-migrant sending households experienced poor distribution of rainfall. The greatest disparity in rates of migration by household occurred where the distribution of rainfall was worse than

[141] Bylander, "Cambodian Migration to Thailand: The Role of Environmental Shocks and Stress."

normal, although changes in the amount and onset of rainfall also had large differences. Additionally, 14% of households that sent migrants in 2009 also reported significant crop losses in their previous harvest (Figure 19). Only 4% of households not sending migrants reported crop losses.

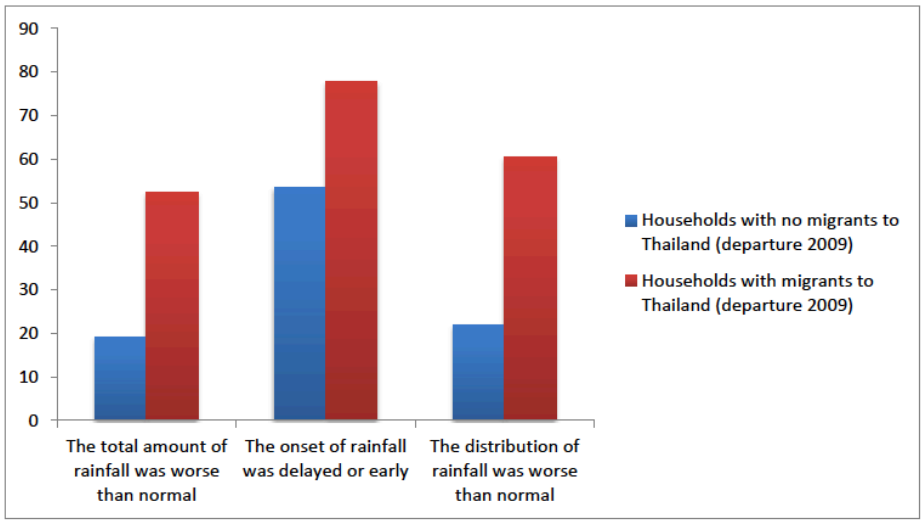

Figure 18: Percent of Households Reporting Rainfall Insecurity[142]

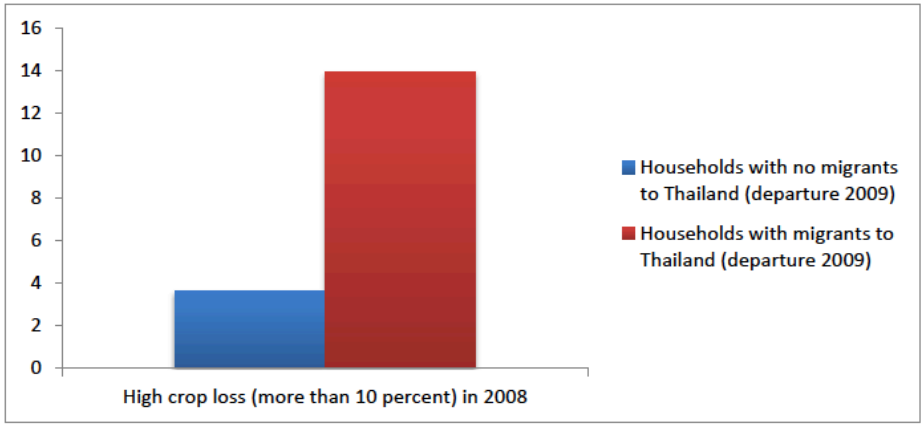

Figure 19: Percent of Households Reporting Crop Losses[143]

[142] Figure from Bylander.
[143] Figure from Bylander.

Multivariate models by Bylander, controlling for other explanatory factors, found the households that experienced crop loss were two times as likely to have a family member migrate.[144] Households that experienced drought were three times more likely to have a family member migrate. Households that reported poor rainfall were two times more likely to have a family member migrate. Flooding had no significant association with migration. A final analysis found that households that experienced crop loss (not in a drought context) were more likely to migrate than households in a drought context (but not experiencing crop loss). This suggests that migration is a response to environmental sensitivity and the risk to livelihoods rather than a direct response to climate shocks. However, it is important to note that the decision to migrate does not occur in a vacuum, and other key drivers such as indebtedness, displacement, and family migration due to marriage continue to affect rural Cambodians' decision to migrate.

[144] Bylander.

Chapter 5: Discussion

Given the results explored in Chapter 4, it is clear that future climate change will affect migration patterns in Cambodia. The country has the necessary preconditions for climate migration: low adaptive capacity, poor social safety nets, and low government legitimacy. Despite improvements in the standard of living and other economic measures of wellbeing, Cambodia remains a fragile state and its citizens are highly vulnerable to the effects of climate change. As elucidated in the focus group surveys, Cambodians are effectively one disaster or event away from being unable to care for themselves or their families.

The climate analysis results demonstrated an increase in drying in the northwest region of the country, which is also highly dependent on agriculture. These drying trends are intensifying, suggesting that future climate effects will continue the trend. An important part of the analysis is the comparison of precipitation trends and rice production. Some of the heaviest rice production in Cambodia occurs in the northwest portion of the country, which is also the most affected by drying trends. These are also regions that are very rural and reliant on agriculture, particularly in Banteay Meanchey. The focus groups said inadequate rainfall meant they would be unable to plant and grow rice crops, or their harvests would be greatly reduced. Thus, changes in the variability of water is critically important for the success or failure of rice harvests. Households in these regions will have to find coping mechanisms to adapt to climate change effects.

One such coping mechanism is migration, and research has shown a significant link between rainfall insecurity, crop losses, and migration. Rainfall insecurity during the previous year and crop losses during the previous harvest season both had the effect of increasing migration to Thailand during the following year. These conclusions are

supported by the focus group results – respondents often noted that if climate change affected their crop cycles too much, they would have to migrate to seek work along the Thai border.

This research is important in two ways: first, it uses novel spatiotemporal analysis techniques to identify regions of Cambodia that are more vulnerable to the effects of climate change than others. These regions are primarily in the northwest of the country and are experiencing intensifying drying trends. Second, using existing research, this study explores a pathway between climate change and migration, concluding that rainfall scarcity does lead to migration in the Cambodian context. Knowing that the northwest is the most vulnerable to rainfall scarcity and that rainfall scarcity can lead to migration, this research thus indicates that the northwestern provinces of Banteay Meanchey, Battambang, and Siem Reap are the most likely to experience climate-induced migration. If precipitation continues to diminish, we will likely see an increase in migration from these provinces.

Based on these results, funding needs to be devoted to additional research on the effects of climate change on migration in Cambodia, especially in the northwestern provinces. Additionally, the Cambodian government and international organizations should direct funding towards policies that increase the resilience of the region's agricultural communities. Clearly, vulnerable households are unable to adapt to climate change and turn towards migration as a coping mechanism. This has the potential to stress finite government resources or lead to tensions along the Cambodian-Thai border. Such policies could include expanding existing climate initiatives, improving climate-resilient development, and improving labor and migration policies with an eye towards future drivers of migration.

Chapter 6: Conclusion

The purpose of this research was to analyze climate vulnerabilities and security risks in Cambodia. This research used a combination of quantitative data measures and qualitative surveys to offer a holistic picture of the relationship between rainfall variability and migration in Cambodia. Ultimately, it concluded that that precipitation is decreasing in the northwest portion of the country. This, in turn, leaves northwestern Cambodia vulnerable to climate-induced crop losses and increased migration to Thailand.

The Cambodian government and international organizations should direct funding towards research to better understand the situation in northwestern Cambodia and policies that increase the resilience of the region's agricultural communities. Future research should address two things: first, how climate change projections for the county vary spatially and temporally; and second, how climate change and migration are linked in a robust study that addresses all potential reasons for migration. Cambodian policymakers need quality spatially disaggregated data that projects climate effects into the future to adequately plan for changes. Additionally, more research needs to be done to disentangle the many factors that contribute to the decision to migrate and which provinces are sending the most climate migrants.

Ultimately, climate change poses a high risk to agricultural productivity in the northwest portion of the country and will likely lead to increased migration from that area – this research elucidates that trend. Cambodian and international policymakers should use this study to conduct research and implement policies that increase the resilience of the region's vulnerable communities.

Appendices

A - Province Spellings by Admin Code

1. Banteay Meanchey
2. Battambang
3. Kampong Cham
4. Kampong Chhnang
5. Kampong Speu
6. Kampong Thom
7. Kampot
8. Kandal
9. Koh Kong
10. Kratie
11. Mondul Kiri
12. Phnom Penh
13. Preah Vihear
14. Prey Veng
15. Pursat
16. Ratanak Kiri
17. Siem Reap
18. Preah Sihanouk
19. Stung Treng
20. Svay Rieng
21. Takeo
22. Oddar Meanchey
23. Kep
24. Pailin
25. Tboung Khmum

B - FOCUS GROUP SURVEYS

Introduction/Purpose

Explain purpose of research: to determine local climate change perceptions and understand how people are able to adapt. To understand how climate change stresses communities and if it can lead to conflict.

I wish to write notes on this conversation for my own records – is that ok? The notes will be kept anonymous. No identifying information about you will be written down or published. Answers will be kept anonymous in any final product.

Background

Date:

Province:

District:

Village/commune:

Interviewer(s):

Translator(s):

Number of people in focus group:

Age(s):

Gender(s):

Est. years of schooling:

Est. # of hectares/rai:

Perceptions of Group:

Climate Change Questions

1. What do you do for a living?
2. In the past 5 years, have you experienced any form of flood damage?
3. In the past 5 years, have you experienced any hardship from drought?
4. Which concerns you more, flooding or droughts?
5. Do you feel the weather is generally changing?
6. Have you noticed any changes in rainfall? In the monsoon season?
7. Has your fish harvest or rice crop changed in the past few years?
    a. If yes: do people get angry over it? Worried? What do they blame it on?
8. Have any major climate events impacted agriculture? What is your perception of the level of risk? Do you have any stories to support this?
9. Do villagers notice changes in rice yields?
10. Do you worry about your livelihood?
11. Have you heard of the phrase "climate change" or "global warming"? What do you know about it?
12. Have any government agencies or NGOs helped train you about climate change? Has this helped you? In what ways?

Adaptation Questions

1. In the past 5 years, have you noticed too much or too little rain?
2. When you have too much rain in a year, what do you do?
3. When you have too little rain in a year, what do you do?
4. If flooding damages your house or crop, what do you do?
5. If someone in your family gets sick, what do you do?
6. What do you do if the fish harvest is poor?
7. Where do you get your water? Do you usually have clean water?

8. What is your main food source?

9. Do you have any savings or financial assets? If something bad were to happen, would you feel financially prepared for it?

10. Are you able to plan for the future, or do you feel you are always catching up to things?

11. What do you do to reduce climate risk?

12. Have you implemented any climate smart technologies? Are new technologies hard to adopt? What makes you ready to adopt climate smart technologies?

13. Do government agencies or NGOs ever support your efforts to plan for the harvest? What training programs have you done to help learn about climate change adaptation?

Security Questions

1. When you have a year with too little rain, how do people usually react?
2. When you have a year with too much rain, how do people usually react?
3. What changes have villagers noticed about the weather? How do they feel about it – angry? Worried?
4. Do people in your community ever fight over resources such as water, rice, or fish? How do they resolve it?
5. If you and a neighbor disagreed over who gets to use a resource (such as water), what would you do about it?
6. If you think something is unfair, what would you do about it?
7. Have people in your village heard about dams that could impact the flooding of the Mekong? What do they think?

    a. If the water went away, who's fault would it be? What would you do about it?

8. What do young people do in the villages?
    a. Do any of them leave? If so, why?
9. If the price of food increases, what do you do? Whose fault would it be?

C - Institutional Review Board Correspondence

Subject: RE: IRB & Research Question
Date: Monday, April 27, 2020 at 12:52:46 PM Central Daylight Time
From: Murphy, Emily M
To: Laura Sigelmann

Hi Laura,

Thank you for taking the time to email and speak with me over the phone. Per our conversation nearly a year ago, the purpose of this research is for thesis use only and does not require IRB approval.

Should you need anything further, please feel free to contact me directly, as I'm happy to assist!

Kind regards,
Emily

From: Laura Sigelmann <laura.e.sigelmann@gmail.com>
Sent: Monday, April 27, 2020 10:39 AM
To: Murphy, Emily M <e.murphy@austin.utexas.edu>; IRB <irb@austin.utexas.edu>
Subject: Re: IRB & Research Question

Hello-

Last year we spoke about my thesis and IRB approval. We concluded that it did not require IRB approval in this scenario. I'm on the cusp of turning it in, and need an official statement such as a letter that I did not require approval. I would love to chat about this and am available via (206) 245-5210 any time.

I've attached the email correspondence below.

Best,

--
Laura E. Sigelmann

M.A. Global Policy Studies | LBJ School of Public Affairs
M.S. Energy and Earth Resources | University of Texas Jackson School of the Geosciences
B.A. Earth and Environmental Science | Vanderbilt University 2013

Phone: 206-245-5210
Email
LinkedIn

From: Laura Sigelmann <laura.e.sigelmann@gmail.com>
Date: Monday, November 18, 2019 at 3:51 PM
To: "Murphy, Emily M" <e.murphy@austin.utexas.edu>
Subject: Re: IRB & Research Question

Yes, I am available tomorrow from 2pm to 5pm.

My phone number is (206) 245-5210.

Best,
--
Laura E. Sigelmann

M.A. Global Policy Studies | LBJ School of Public Affairs
M.S. Energy and Earth Resources | University of Texas Jackson School of the Geosciences
B.A. Earth and Environmental Science | Vanderbilt University 2013

Phone: 206-245-5210
Email
LinkedIn

From: "Murphy, Emily M" <e.murphy@austin.utexas.edu>
Date: Monday, November 18, 2019 at 3:05 PM
To: "laura.e.sigelmann@gmail.com" <laura.e.sigelmann@gmail.com>
Subject: RE: IRB & Research Question

Good day Lauren,

Would you be available for to discuss this over the phone tomorrow afternoon?

If so please provide the best phone number to reach you by as well as the best times for your schedule.

Kindly,

Emily

From: Laura Sigelmann <laura.e.sigelmann@gmail.com>
Sent: Friday, November 15, 2019 12:39 AM
To: IRB <irb@austin.utexas.edu>
Subject: IRB & Research Question

Hello-

This past December, I completed focus group research in Cambodia as part of a project on climate vulnerability and state fragility. Due to a miscommunication with my advisor (and no prior experience with qualitative research or knowledge of what was required of me), I did not know whether I needed IRB approval and did not apply. As a precaution, the research was not published and my final paper was only turned in for internal administrative purposes.

As I am working on my thesis (on climate change and security consequences in Cambodia), I'm realizing that the interviews I completed are incredibly valuable for my current work and I am unable to return to Cambodia to re-do the research. There were a couple trends that I picked up during the interviews that I want to investigate in my thesis, and having that qualitative interview data would add to the strength of my argument. I was wondering a) if IRB is required in this scenario and b) if so, is there any way to remedy this.

The focus groups were as follows. When in Cambodia, I connected with a local NGO that had climate-resilient development projects underway, and they brought me to interview communities that they were working

with. The groups I interviewed were 2 women's empowerment groups of 15 people and 1 climate-smart village of 4 people. All groups were already under project implementation with the NGO (Aphivat Strey). I have documentation of the development of my questions (done with the NGO project coordinator) and the results. None of the groups were recorded and their answers were documented on paper via a translator.

Any advice is much appreciated, and I am also happy to talk on the phone!

Best,
--
Laura E. Sigelmann

M.A. Global Policy Studies | LBJ School of Public Affairs
M.S. Energy and Earth Resources | University of Texas Jackson School of the Geosciences
B.A. Earth and Environmental Science | Vanderbilt University 2013

Phone: 206-245-5210
Email
LinkedIn

D - DEMOGRAPHIC AND HEALTH SURVEYS AUTHORIZATION LETTER

Mar 01, 2020

LAURA SIGELMANN
UT Austin
United States
Phone: 2062455210
Email: lsigelmann@utexas.edu
Request Date: 02/29/2020

Dear LAURA SIGELMANN:

This is to confirm that you are approved to use the following Survey Datasets for your registered research paper titled: "Thesis - Climate Change and Migration in Cambodia":

Cambodia

To access the datasets, please login at: https://www.dhsprogram.com/data/dataset_admin/login_main.cfm. The user name is the registered email address, and the password is the one selected during registration.

The IRB-approved procedures for DHS public-use datasets do not in any way allow respondents, households, or sample communities to be identified. There are no names of individuals or household addresses in the data files. The geographic identifiers only go down to the regional level (where regions are typically very large geographical areas encompassing several states/provinces). Each enumeration area (Primary Sampling Unit) has a PSU number in the data file, but the PSU numbers do not have any labels to indicate their names or locations. In surveys that collect GIS coordinates in the field, the coordinates are only for the enumeration area (EA) as a whole, and not for individual households, and the measured coordinates are randomly displaced within a large geographic area so that specific enumeration areas cannot be identified.

The DHS Data may be used only for the purpose of statistical reporting and analysis, and only for your registered research. To use the data for another purpose, a new research project must be registered. All DHS data should be treated as confidential, and no effort should be made to identify any household or individual respondent interviewed in the survey. Please reference the complete terms of use at: https://dhsprogram.com/Data/terms-of-use.cfm.

The data must not be passed on to other researchers without the written consent of DHS. However, if you have coresearchers registered in your account for this research paper, you are authorized to share the data with them. All data users are required to submit an electronic copy (pdf) of any reports/publications resulting from using the DHS data files to: references@dhsprogram.com.

Sincerely,

Bridgette Wellington

Bridgette Wellington
Data Archivist
The Demographic and Health Surveys (DHS) Program

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